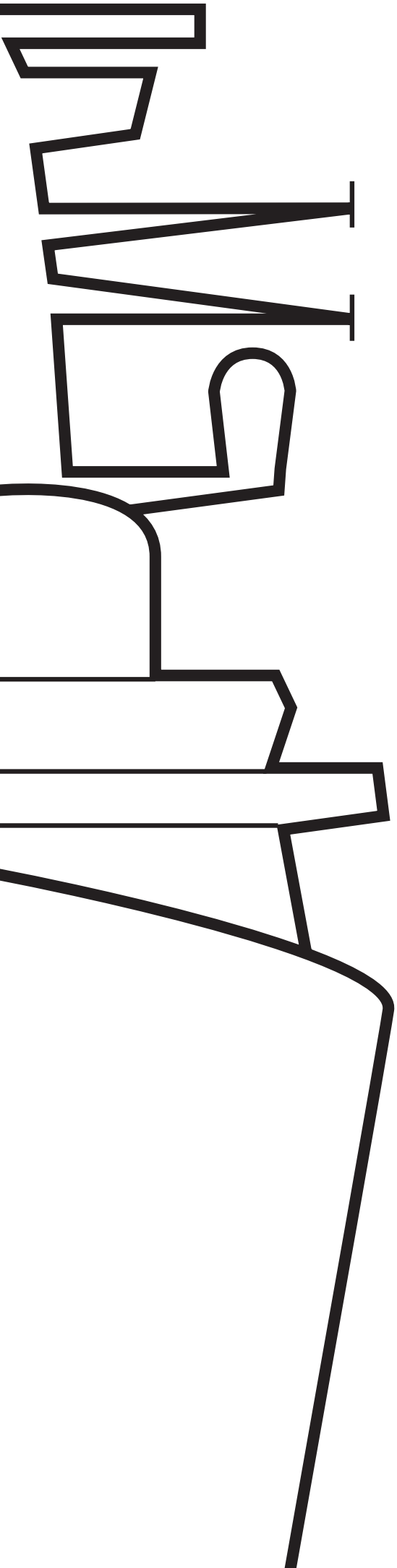


Rules and Regulations for the Classification of Naval Ships, January 2005

Notice No. 1

Effective Date of Latest Amendments:

See page 1

Issue date: November 2005

Lloyd's Register

RULES AND REGULATIONS FOR THE CLASSIFICATION OF NAVAL SHIPS, *January 2005*

Notice No. 1

This Notice contains amendments within the following Sections of the *Rules and Regulations for the Classification of Naval Ships, January 2005.* The amendments are effective on the dates shown:

Volume	*Part*	*Chapter*	*Section*	*Effective date*
1	1	1	7	1 January 2005
1	1	2	1-9	1 July 2005
1	1	3	1, 2, 4, 5, 6, 13, 16, 17	1 July 2005
1	3	2	5	1 January 2005
1	3	3	2	1 January 2005
1	3	4	4, 5, 6, 8	1 January 2005
1	3	5	2, 4, 8	1 January 2005
1	4	1	6	Corrigendum
1	4	2	2	Corrigenda
1	4	3	3, 4	1 January 2005
1	5	3	3, 4	Corrigenda
1	6	3	3	1 January 2005
1	6	6	4	Corrigendum
2	1	1	8	1 January 2005
2	1	2	3, 4, 5, 18	1 January 2005
2	1	2	17	Corrigenda
2	2	1	2, 3, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15	1 January 2005
2	2	3	7	1 January 2005
2	3	2	4	1 January 2005
2	4	4	2	Corrigenda
2	5	4	2	1 January 2005
2	7	1	2, 4, 5, 8, 12, 18	1 January 2005
2	7	3	4, 10, 11	1 January 2005
2	7	4	3	1 January 2005
2	9	1	2	1 January 2005
2	10	1	1, 3, 5, 7, 19	1 January 2005
2	10	1	1	Corrigenda
2	11	3	1, 2, 4, 5, 6	1 January 2005
3	1	4	1, 2, 3, 4, 5	1 January 2005
3	1	5	1	1 January 2005
3	1	5	2	Corrigenda
3	1	7	2	Corrigendum
3	2	2	2, 3	1 January 2005

It will be noted that the amendments also include corrigenda, which are effective from the date of this Notice.

The *Rules and Regulations for the Classification of Naval Ships, January 2005* are to be read in conjunction with this Notice No. 1. The status of the Rules is now:

Rules for Naval Ships	Effective date: January 2005
Notice No. 1	Effective dates: 1 January 2005, 1 July 2005 & Corrigenda

Volume 1, Part 1, Chapter 1
General Regulations

(Effective date 1 January 2005)

■ *Section 7*

7.1 The Committee has power to adopt, and publish as deemed necessary, Rules relating to classification and has (in relation thereto) provided the following:

(a) Except in the case of a special directive by the Committee, no new Regulation or alteration to any existing Regulation relating to character of classification or to class notations is to be applied to existing ships.

(b) Except in the case of a special directive by the Committee, or where changes necessitated by mandatory implementation of International Conventions, Codes or Unified Requirements adopted by the International Association of Classification Societies are concerned, no new Rule or alteration in any existing Rule is to be applied compulsorily after the date on which the contract between the ship builder and ship owner for construction of the ship has been signed, nor within six months of its adoption. ~~Where it is desired to use existing approved ship or machinery plans for a new contract, written application is to be made to the Committee.~~ The date of 'contract for construction' of a ship is the date on which the contract to build the ship is signed between the prospective ship owner and the ship builder. This date is normally to be declared to the Committee by the party applying for the assignment of class to a newbuilding. The date of 'contract for construction' of a series of sister ships, including specified optional ships for which the option is ultimately exercised, is the date on which the contract to build the series is signed between the prospective ship owner and the ship builder. In this section sister ships are ships built to the same approved plans for classification purposes. The optional ships will be considered part of the same series of sister ships if the option is exercised not later than 1 year after the contract to build the series was signed. If a contract for construction is later amended to include additional ships or additional options, the date of 'contract for construction' for such ships is the date on which the amendment to the contract is signed between the prospective ship owner and the ship builder. The amendment to the contract is to be considered as a 'new contract'. Where it is desired to use existing approved ship or machinery plans for a new contract, written application is to be made to the Committee.

NOTE

Sister ships may have minor design alterations provided that such alterations do not affect matters related to classification.

(c) All reports of survey are to be made by Surveyors authorised by LR to survey and report (hereinafter referred as the Surveyors) according to the form prescribed, and submitted for the consideration of the Committee, or its Sub-Committee of Classification, but the character assigned by the latter is to be subject to confirmation by the Committee or by the Chairman acting on behalf of the Committee.

(d) Information contained in the reports of classification and statutory surveys will be made available to the relevant owner, National Administration, Port State Administration, P&I Club, hull underwriter and, if authorized in writing by that owner, to any other person or organization.

(e) Information relating to the status of classification and statutory surveys and suspensions/withdrawls of class together with any associated conditions of class will be made available as required by applicable legislation or court order.

(f) A Classification Executive consisting of senior members of LR's Classification Department staff shall carry out whatever duties that may be within the function of the Sub-Committee of Classification that the Sub-Committee of Classification assigns to it.

Volume 1, Part 1, Chapter 2
Classification Regulations

(Effective date 1 July 2005)

■ *Section 1*
Conditions for Classification

1.2 Application

1.2.3 At the discretion of LR, ship types which are specifically covered by LR's *Rules and Regulations for the Classification of Ships* or other LR Rules and Regulations for Classification may be considered for classification in accordance with these Rules and Regulations. *See* 9.1.1.

■ *Section 2*
Scope of the Rules

2.1 Applicable ship types

(Part only shown)

2.1.1 The Rules are applicable to naval ships designed and constructed for the purpose of carrying and operating naval systems. For the purposes of Classification, naval ships can be grouped into ~~three~~ four categories as follows:

(d) **NSA ships**

This category covers auxiliary naval ships used for the support of civil and naval operations. They may have a variety of roles including the movement of military and other personnel, ammunition, vehicles, stores and fuels and the transfer of such to other naval ships. They do not have a defined offensive role but may have a limited self-defence capability. In general, the ships will comply with LR's Rules for Ships and any relevant requirements in Ch 3,17 and satisfy as far as practicable the requirements of the International Conventions applicable to the ship type. Any deviation from the applicable International Convention requires agreement with the Navy or Naval Authority and where applicable the National Administration. A Design and Operating Scenario Statement declared by the Navy stating the role of the ship in terms of the carriage of equipment, personnel, stores and fuels is to be acceptable to LR. The assignment of the **NSA** ship type notation is dependent on the ship being in Machinery Naval Class with the **✠LMC**, **✠LMC**, [✠]LMC, **LMC** or **MCH** notations.

■ *Section 3*
Character of Classification and Class notations

3.1 General

3.1.5 The following are examples of character symbols, and Class notations as they would appear in the *Register Book*:

~~✠ 100A1 NS2 Frigate,~~
~~✠ LMC, SCM, SA1, SDA, ESA1, RSA2, Ice Class 1C,~~
~~✠ MD, SEA, EER.~~

✠ 100A1 NS2 Frigate, SA1, AIR
✠ LMC, SCM, SDA, ESA1, RSA2, Ice Class 1C
✠ MD, SEA, EER.

3.2 Character symbols

3.2.5 The Navy or Naval Authority may specify alternative or additional standards/requirements relating to the application of a character symbol or Class notation. Where these alternative or additional standards/requirements have been agreed by LR and a formal process for approval, construction, testing and verification throughout life has been established, this feature will be recognised by the addition of **(NS)** to a character symbol or Class notation. The alternative or additional requirements of the Navy or Naval Authority are to be clearly defined and referenced in the Classification Certificates and any required registers such as the register of lifting appliances. The following are examples of character symbols and Class notations that may recognize Navy or Naval Authority requirements as they may appear in the *Register Book*:

A(NS) Ship built or accepted into Naval Class in accordance with LR's Rules and Regulations for assignment of the **A** character and defined Navy or Naval Authority requirements.

✠LMC(NS) Propelling and essential auxiliary machinery constructed, installed and tested under Special Survey in accordance with LR's Rules and Regulations for assignment of **✠LMC** Class notation and defined Navy or Naval Authority requirements.

LA(NS) Lifting appliances designed and built in accordance with LR's *Code for Lifting Appliances in a Marine Environment* (LAME) or equivalent standard for assignment of **LA** Class notation and additional defined requirements of the Navy or Naval Authority.

FIRE(NS) Fire protection functional requirements are in accordance with LR's requirements for assignment of **FIRE** Class notation and additional requirements of the Navy or Naval Authority.

3.2.6 Proposals to apply the additional Navy or Naval Authority recognition symbol **(NS)** to a character symbol or Class notation are to be made to LR with details of the Navy or Naval Authority requirements together with proposed processes for approval, construction, testing and verification throughout life.

3.4 Ship type notations

3.4.2 A list of ship type notations for which a ship may be eligible is:

NS1 This notation will be assigned to NS1 category naval ships, as defined in Section 2.1.1(a).

NS2 This notation will be assigned to NS2 category naval ships, as defined in Section 2.1.1(b).

NS3 This notation will be assigned to NS3 category naval ships, as defined in Section 2.1.1(c).

NSA This notation will be assigned to NSA category naval ships, as defined in Section 2.1.1(d).

3.4.3 The ship type notation will be followed by a description which indicates the operational role for which the ship is designed and the hull form type, if of unusual form. The following are examples of the description of the ship's role:

Destroyer
Cruiser
Helicopter Carrier
Aircraft Carrier
Frigate
Corvette
Amphibious Assault Ship
Amphibious Transport Dock
Landing Craft
Landing Ship Dock
Minehunter
Minelayer
Mine-sweeper
Patrol ship
Fast Attack Craft
Fast Strike Craft
Fast Patrol Craft
Offshore Patrol Vessel.
~~Survey ship~~.

3.4.4 The **NSA** ship type notation will be followed by a description which indicates the operational role for which the ship is designed and operated. The following are examples of the description of an NSA ship's role:

Replenishment Ship
Oil Supply Ship
Landing Ship Dock
Survey Ship
Stores Replenishment Ship
Transport Dock
Ro-Ro Ship
Troop Carrier
Vehicle Carrier
Landing Craft
Air Cushioned Support Vehicle.

3.4.5 **Design and Operating Scenario Statement:** This is required for **NSA** ships and is to detail the civil and naval support functions of the ship. The statement is to include but is not limited to the following:

(a) Types and volumes of stores, equipment, fuels and ordnance to be carried on board.
(b) The number of crew and embarked personnel to be carried on board.
(c) International Conventions that will be applied to the ship; and any National Administration requirements that will be applied together with details of any exemptions that are being considered.
(d) National Administration and their involvement in approval and operation in service.
(e) Naval Ship Class notations that will be applied to the ship.
(f) The Rules used for design and construction of the hull structure and machinery systems.
(g) Proposed survey periodicity.
(h) Installed combat systems.
(j) Installed handling equipment for stores and equipment.
(k) Design survivability of the ship.
(l) Operational modes of the ship.

The statement is to be submitted at the time of submitting the Request for LR Services form and LR will advise acceptance of the contents of the statement before proceeding with detailed analysis of other plans and information required for classification purposes.

Table 2.3.1 Hull, Military and Other Class Notations *(Part only shown)*

Mandatory Notations		Other Notations		
Ship Type	Service Area	Hull Strength	Military Distinction ✠ MD	Others
See 3.4 (Select one:) **NS1** **NS2** **NS3** **NSA** Description of ship's role Examples: Cruiser Helicopter Carrier Aircraft Carrier Destroyer Frigate Corvette Amphibious Assault Ship Amphibious Transport Dock Landing Craft Minehunter Minelayer Mine-sweeper Patrol Ship Survey Ship e.g. NS1 Helicopter Carrier Oil Supply Ship Landing Ship Dock Survey Ship Stores Replenishment Ship Transport Dock Ro-Ro Ship Troop Carrier Vehicle Carrier Air Cushioned Support Vehicle Military Operations **AIR** Aircraft Operations	*See* 3.5 (Select one:) **SA1** Service Area 1 **SA2** Service Area 2 **SA3** Service Area 3 **SA4** Service Area 4 **SAR** Service Area Restricted	*See* 3.6 **ESA1 ESA2** Extreme Strength Assessment **RSA1 RSA2 RSA3** Residual Strength Assessment **TLA** Total Load Assessment **SDA** Structural Design Assessment **FDA** Fatigue Design Assessment	*See* 3.7 **IB1 IB2** Internal Air Blast **EB1 EB2 EB3 EB4** External Air Blast **SH1 SH2 SH3** Shock Enhancement **WH1 WH2 WH3** Whipping Assessment **FP1 FP2** Fragmentation Protection **SP** Small Arms Protection	*See* 3.9 **LA LA(N)** Lifting Appliances **SD** Special Duties **CM** Construction Monitoring **SEA (HSS-n)** Ship Event Analysis Hull Surveillance System **SEA (VDR)** Ship Event Analysis Voyage Data Recorder **SEA (VDR-n)** Sea Event Analysis Voyage Data Recorder (strain gauges) **ES** Enhanced Scantlings **SERS** Ship Emergency Response Service **EER** Escape, Emergency Access, Evacuation and Rescue (*see* Note) **FIRE** Fire Protection (*see* Note) **LSAE** Life Saving and Evacuation (*see* Note) **ESC** Escape and Emergency Access (*see* Note) **SNC** Safety of Navigation and Communication (*see* Note) **POL** Pollution Prevention **Ice Class** Navigation in Ice **LMA** Manoeuvring Assessment **CEPAC** Crew and Embarked Personnel Comfort **EP** Environmental Protection **$\overline{\text{EP}}$** Environmental protection **LI** Approved Loading Instrument **HPMS** Hull Planned Maintenance Scheme

Table 2.3.2 Machinery Class Notations *(Part only shown)*

Machinery Notations *See* 3.8		
✠ LMC Propulsion and essential machinery	**AG1** Enhanced analysis of propulsion and/or auxiliary gear elements	**RAS(B)** Replenishment at Sea, Abeam
✠̄ LMC Propulsion and essential machinery	**AG2** Enhanced three dimensional finite element analysis of propulsion and/or auxiliary gear elements	**RAS(V)** Replenishment at Sea, VERTREP
[✠] LMC Propulsion and essential machinery	**AP1** Enhanced assessment of propeller manufacturing tolerances on fast ships and craft	**(NT)** Additional to **RAS( )**, NATO requirements
LMC Propulsion and essential machinery	**AP2** Enhanced assessment of propeller manufacturing tolerances having reduced noise characteristics	**UMS** Unattended Machinery Spaces
MCH Propulsion and essential machinery	**MPMS** Machinery Planned Maintenance Scheme	**CCS** Centralised Control Station
SCM Screwshaft Condition Monitoring	**MCM** Machinery Planned Maintenance Scheme with Condition Monitoring	**ICC** Integrated Computer Control
TCM Turbine Condition Monitoring		**IP** Integrated Propulsion
		DP(CM) Dynamic Positioning (Centralised Remote Manual Controls)

3.8 Machinery and Engineering Systems notations

(Part only shown)

3.8.1 The following class notations are associated with the machinery construction and arrangement, and may be assigned:

[✠]LMC This notation will be assigned when the propelling arrangements, steering systems, pressure vessels and the electrical equipment for essential systems have been constructed, installed and tested under LR's Special Survey and are in accordance with LR's *Rules and Regulations for the Classification of Naval Ships*. Other items of machinery for propulsion and electrical power generation including propulsion gearing arrangements and other auxiliary machinery for essential services that are in compliance with LR Rules and supplied with the manufacturer's certificate will be acceptable under this notation. The system arrangements of propelling and essential auxiliary machinery are required to be appraised by LR, and found to be acceptable to LR. *See* 3.10.2.

LMC This notation (without ✠) will be assigned when the propelling and essential auxiliary machinery has neither been constructed nor installed under Special Survey, but the existing machinery its installation and arrangement has been tested and found acceptable. This notation is assigned to existing ships in service accepted or transferring into LR class.

MCH This notation will be assigned when the propelling and essential auxiliary machinery has been installed and tested under LR's survey requirements and found to be acceptable to LR. Items of machinery and equipment for propelling and auxiliary machinery for essential services supplied with the manufacturer's certificate will be acceptable under this class notation. The system arrangements of propelling and essential auxiliary machinery are required to be appraised by LR, and found to be acceptable to LR. *See* 3.10.3.

3.9 Other notations

~~*3.9.3* **LA(N).** Where additional requirements of the Naval Authority have been complied with, the ship will be entitled to the notation **LA(N).** These requirements are to be clearly defined and referenced in the register of lifting appliances.~~

Existing paragraphs 3.9.4 to 3.9.17 are to be renumbered 3.9.3 to 3.9.16.

~~*3.9.18* **EP.** This notation will be assigned where the environmental protection arrangements for prevention of pollution of the sea and of the air demonstrate compliance with the relevant annexes of MARPOL. It denotes that the assessment for compliance with MARPOL has been carried out in accordance with LR's Rules. Supplementary characters **A** Anti-fouling coatings, **B** Ballast water management, **F** Protected fuel tanks, **G** Grey water, **N** Oxides of nitrogen in exhaust emissions, **R** Refrigeration systems and **S** Oxides of sulphur in exhaust emissions reflect compliance with additional requirements.~~

3.9.17 **EP.** This notation will be assigned where the environmental protection arrangements for prevention of pollution of the sea and of the air demonstrate compliance with the Rules. Supplementary characters **A** Anti-fouling coatings, **B** Ballast water management, **F** Protected fuel tanks, **G** Grey water, **N** Oxides of nitrogen in exhaust emissions, **R** Refrigeration systems, **S** Oxides of sulphur in exhaust emissions and **O** Oily bilge water reflect compliance with additional requirements.

3.9.18 **$\overline{\text{EP}}$.** This notation will be assigned when the environmental protection arrangements are in accordance with the requirements of another recognised classification society and are broadly equivalent to the LR Environmental Protection Rule requirements. Prior to assignment of the notation, an audit, in accordance with the requirements in Vol 3, Pt 1, Ch 2,4.1.3 and 4.1.4 of the Rules, is to be undertaken by Lloyd's Register to confirm that the necessary Environmental Protection procedures are in place and implemented effectively.

3.9.22 ***IWS.** This notation (In-water Survey) may be assigned to a ship where the applicable LR requirements are complied with, *see* Section 7 and Ch 3,4.3.

3.10 Application notes

3.10.1 **Propelling and essential auxiliary machinery** includes machinery, equipment and systems installed for the ship to be under seagoing conditions and that are necessary for the following:

(a) Maintaining the watertight and weathertight integrity of the hull and spaces within the hull.
(b) The safety of the ship, machinery and personnel on board.
(c) The functioning and dependability of propulsion, steering, electrical, ship type and support systems.
(d) The operation and functioning of control engineering systems for the monitoring and safety of propulsion, steering, ship type and support systems.
(e) The operation and functioning of emergency machinery and equipment.
(f) The operation and functioning of machinery and equipment for harbour use and that can also be used while the vessel is at sea.

3.10.2 **Manufacturer's certificate** for assignment of the **[✠]LMC** notation. Acceptance of the manufacturer's certificate for items of machinery for propulsion (including propulsion gearing with single input/output arrangements) and for electrical power generation and for other auxiliary machinery for essential services is subject to the following:

(a) The vessel is an NS3 ship or an NSA ship of less than 500 gross tonnage or is a ship of 500 gross tonnage or greater and is not required to comply with international conventions applicable to a ship with unrestricted service.
(b) Propulsion power is provided by oil engines or gas turbines which have been type approved to LR's requirements for marine application.

(c) Electrical power is provided by generators driven by oil engines or gas turbines which have been type approved to LR's requirements for marine application.
(d) The design and manufacture standards for all machinery and associated systems are the applicable LR Rules.
(e) The machinery and equipment is manufactured under a recognised quality control system.
(f) Propellers, propulsion shafting and multiple input/output gearboxes are not included within the scope of propulsion arrangements for acceptance of a manufacturer's certificate.

See Section 6.

3.10.3 **Manufacturer's certificate** for assignment of the **MCH** notation. Acceptance of the manufacturer's certificate for propelling and essential auxiliary machinery is subject to the following:

(a) The ship is an NS3 ship or an NSA ship of less than 500 gross tonnage or is a ship of 500 gross tonnage or greater and is not required to comply with international conventions applicable to a ship with unrestricted service.
(b) Propulsion power is provided by oil engines or gas turbines which have been type approved to LR's requirements for marine application
(c) Electrical power is provided by generators driven by oil engines or gas turbines which have been type approved to LR's requirements for marine application.
(d) The power of any engine or gas turbine is less than 2,250 kW and the cylinder bore of any diesel engine is not greater than 300 mm.
(e) The design standards for machinery and associated systems are the applicable LR Rules or other marine standards acceptable to LR.
(f) The machinery and equipment is manufactured under a recognised quality control system.

See Section 6.

3.10.4 **Gross tonnage** of a vessel is to be determined for the purposes of these Rules and Regulations, by the following formula:

$$GT = K_1 V$$

where:

V = total volume of all enclosed spaces in the vessel in cubic metres and includes gun turrets, radar domes, masts, etc.

$K_1 = 0{,}2 + 0{,}02 \log_{10} V$.

■ *Section 4* Surveys – General

4.4 Damages, repairs and alterations

4.4.2 Any damage in association with wastage over the allowable limit (including buckling, grooving, detachment or fracture), or extensive areas of wastage over the allowable limits, which affects or, in the opinion of the Surveyor, will affect the ship's structural, watertight or weathertight integrity, is to be promptly and thoroughly repaired. Areas to be considered include, (where fitted):

- side shell frames, their end attachments or adjacent shell plating;
- deck structure and deck plating;
- bottom structure and bottom plating;
- side structure and side plating;
- inner bottom structure and inner bottom plating;
- inner side structure and inner side plating;
- watertight or oiltight bulkheads;
- hatch covers or hatch coamings.

For locations where adequate repair facilities are not available, consideration may be given to allow the ship to proceed directly to a repair facility. This may require discharging stores/equipment and/or temporary repairs for the intended voyage.

Existing paragraphs 4.4.2 to 4.4.6 are to be renumbered 4.4.3 to 4.4.7.

4.5 Existing ships – Periodical Surveys

4.5.3 The Owner should notify LR whenever a ship can be examined in dry-dock or on a slipway. An inspection of the underwater hull and its appendages is to be carried out not less than twice every six years. ~~The maximum period between **Docking Surveys** is not to exceed six years, and should coincide with the Special Survey.~~ The maximum period between inspections of the hull and its appendages in dock or in-water is not to exceed three and a half years. Consideration may be given at the discretion of LR to any special circumstances justifying an extension of the maximum periods between inspections ~~this interval~~. A **Docking Survey** is to be carried out concurrently with the ~~considered to coincide with the~~ Special Survey. The required Docking Survey is considered to coincide with the Special Survey when held within the six months prior to the due date of the Special Survey. *See* 4.5.5.

4.5.5 Classification details and Survey requirements for **In-water Surveys** are given in Section 7 and Ch 3,4.3 respectively. ~~to be held concurrent with intermediate surveys.~~ A Docking survey can be carried out in lieu of an ~~IWS~~ In-water Survey for inspection of the underwater hull and appendages between the Docking Surveys that are to be carried out concurrently with the Special Survey. The date of the last In-water Survey will be recorded in the Supplement to the *Register Book*, preceded with the notation ***IWS** ~~record 'IWS'~~.

4.7 Notice of surveys

~~*4.7.2* LR will give timely notice to an Owner about forthcoming surveys by means of a letter or a quarterly computer print-out. The omission of such notice, however, does not absolve the Owner from his responsibility to comply with LR's survey requirements for maintenance of Class.~~

4.7.2 Timely notice to an Owner about forthcoming surveys is available by means of access to LR's ClassDirect Live. The omission of such notice, however, does not absolve the Owner from their responsibility to comply with LR's survey requirements.

4.8 Withdrawal/Suspension of Class

4.8.2 When the Regulations as regards surveys on the hull equipment and machinery have not been complied with and the ship is thereby not entitled to retain Class, the Class will be suspended or withdrawn after consultation with the Owner and a corresponding notation will be assigned. In order to maintain class, LR will require documentary evidence regarding the material state of the ship, its systems and equipment in terms of reports, photographs, measures or videos where the operational requirements exceed 12 months.

■ *Section 5* Type Approval/Type Testing/ Quality Control System

5.1 LR Type Approval

5.1.1 LR Type Approval is an impartial certification system that provides independent third-party Type Approval Certificates attesting to a product's conformity with specific standards or specifications. It is based on design review and type testing or where testing is not appropriate, a design analysis.

5.1.2 The LR Type Approval System is a process whereby a product is assessed in accordance with a specification, standard or code to check that it meets the stated requirements and through selective testing demonstrates compliance with specific performance requirements. The testing is carried out on a prototype or randomly selected product(s) which are representative of the manufactured product under approval. Thereafter, the producer is required to use Quality Assurance procedures and processes to ensure that each item delivered is in conformity with that which has been Type Approved.

5.1.3 The selective testing required by 5.1.2 is to include environmental testing applicable to the product's installation on board a ship classed or intended to be classed with LR.

5.1.4 LR Type Approval does not remove the requirements for inspection and survey procedures required by the Rules for equipment to be installed in ships classed or intended to be classed with LR. Also, LR Type Approval does not remove the requirement for plan appraisal of a system that incorporates Type Approved equipment where required by the Rules.

5.1.5 LR Type Approval is subject to the understanding that the producer's recommendations and instructions for the product and any relevant requirements of the Rules for the Classification of Naval Ships are fulfilled.

5.1.6 The producer supplying equipment or components under Quality Control procedures and processes is to have a recognised quality management system certified by an IACS member or a Notified Body. The Quality Control procedures and processes are to address the production of the product consistent with 5.3.

5.1.7 Where equipment or components have been Type Approved in accordance with specifications and procedures other than LR's, details of the product, certification and testing are to be submitted for consideration where appropriate.

5.2 Type testing

5.2.1 Type testing is an impartial process that provides independent third-party verification that an item of machinery or equipment has satisfactorily undergone a functional type test.

5.2.2 Type testing is carried out against defined performance and test standards for a defined period of time with test conditions varying between minimum and maximum declared design conditions.

5.2.3 Type testing is carried out on a prototype or randomly selected product(s) which are representative of the manufactured product under assessment.

5.2.4 After type testing, mechanical equipment is to be opened out and inspected for damage or excessive wear.

5.2.5 On application from the manufacturer, type tests may be waived for equipment and machinery that has been proven to be reliable in marine service and where compliance with the current applicable standards can be demonstrated. Equipment and machinery that has been previously type tested with satisfactory testing evidence and certification need not have the type tests repeated where previous testing is in compliance with the current testing standards for the equipment.

5.2.6 The acceptance of type testing certification is subject to the understanding that the manufacturer's recommendations and instructions for the product and any relevant requirements of the applicable Rules are fulfilled.

5.3 Quality Control System

5.3.1 A quality control system for the purposes of LR acceptance of materials and machinery refers to a scheme that covers the operational techniques and activities that are used to demonstrate that the quality requirements of a product is in accordance with declared standards.

5.3.2 The quality control system for a particular product extends to all parties involved in the supply chain from manufacture and testing through to delivery of the product.

5.3.3 LR acceptance of machinery and equipment manufactured under a quality control scheme is dependent on the scheme being maintained through a traceable process involving planned audits and spot inspections at the discretion of LR Surveyors. The purpose of the audits and spot inspections is to ensure that the procedures for manufacture and quality control are being maintained in a satisfactory manner.

5.3.4 The use of a quality control system does not remove the requirements for inspection processes that may be required by the Rules applicable to the equipment being supplied with a manufacturer's certificate. Also the use of the quality control system does not remove the requirement for plan appraisal of equipment or systems where required by the Rules.

■ *Section 6*
Classification of machinery with [✠]LMC or MCH notation

6.1 General

6.1.1 After delivery of machinery and equipment with the manufacturer's certificate to the shipyard, Survey at the Shipyard and Periodical Surveys are to be in accordance with the requirements for ships built or accepted into class with the ✠**LMC** notation.

6.2 Appraisal and records

6.2.1 To facilitate survey and compilation of classification records, plans and information required for a ship being accepted into class with the ✠**LMC** notation are to be submitted for appraisal and information. Plans are not required where machinery and equipment has previously been type approved, in these cases it is only necessary to submit details of the machinery and equipment together with details of the previous approval.

6.3 Survey and inspection

6.3.1 The manufacturer's certificate for acceptance of machinery and equipment for assignment of the **[✠]LMC** or **MCH** notation is to be in the English language and include the following information:

(a) Design and manufacturing standard(s) used.
(b) Materials used for construction of key components and their sources.
(c) Details of the quality control system applied during design, manufacture and testing and of any software maintenance.
(d) Details of any type approval or type testing.
(e) Details of installation and testing recommendations for the machinery or equipment.

The manufacturer is to have a recognised quality management system certified by an IACS member or a Notified Body.

6.3.2 The installation and testing of machinery and equipment at the build or fitting-out yard that has been supplied with a manufacturer's certificate is to be in accordance with the requirements applicable to a ship having the ✠**LMC** notation.

■ *Section 7*
Classification of ship with *IWS notation

7.1 General

7.1.1 Where the ***IWS** class notation for In-water Survey is requested, application should be made to the Committee in writing with evidence of the Owner's agreement.

7.1.2 Where the ***IWS** notation is to be assigned, protection of the underwater portion of the hull is to be provided by means of a suitable high resistant paint applied in accordance with the manufacturer's requirements.

7.2 Appraisal and records

7.2.1 To facilitate survey and compilation of classification records, the following plans and particulars are to be submitted to LR for appraisal and information.

(a) Details of how the rudder pintle and bush clearances are to be measured and how the security of the pintles in their sockets are to be verified with the ship afloat.
(b) Details showing how stern bush clearances are to be measured with the ship afloat.
(c) Details of high resistant paint, for information only.

7.2.2 Where the ***IWS** notation is assigned, approved plans and particulars covering the items detailed in 7.2.1 are to be placed on board.

■ *Section 8*
Classification of ship with operational role: Oil Supply Ship

8.1 General

8.1.1 Where the **Oil Supply Ship** description is to be assigned, the requirements in the *Rules and Regulations for the Classification of Ships* relating to oil tankers are to be complied with.

■ *Section 9*
Classification of naval ships using alternative LR Rules

9.1 General

9.1.1 Where it is proposed to class a naval ship with materials of construction and operating parameters not addressed within the scope of the Naval Ship Rules then the appropriate elements of other LR Classification Rules may be used where agreed between the Naval Authority, the Navy, Builder and LR.

Volume 1, Part 1, Chapter 3
Periodical Survey Regulations

(Effective date 1 July 2005)

■ *Section 1*
General

1.5 Definitions

1.5.5 For ships designed to the *Rules and Regulations for the Classification of Ships*, **Substantial Corrosion** is defined as wastage of individual plates and stiffeners in excess of 75 per cent of allowable margins, but within acceptable limits.

1.5.6 For ships designed on a net scantling basis (using for example the *Rules and Regulations for the Classification of Naval Ships*) **Substantial Corrosion** is defined as the wastage of individual plates and stiffeners in excess of the net scantlings, less an allowance for rolling, but within corrosion limits that are applicable for the structure concerned.

1.5.10 A **Deep Tank** is a tank that extends upwards from the ship's bottom or inner bottom to or higher than the lowest deck.

1.5.11 A **Ballast Tank** is a tank which is solely used for salt-water ballast. A space which is used for purposes other than salt-water ballast but may also be used for salt-water ballast will be treated as a salt-water ballast tank when substantial corrosion has been found.

1.6 Preparation for survey and means of access

1.6.1 Tanks and spaces are to be safe for access, i.e. gas freed, ventilated and illuminated.

1.6.2 In preparation for survey, thickness measurements and to allow for a thorough examination, all spaces are to be cleaned including removal from surfaces of all loose accumulated corrosion scale. Spaces are to be sufficiently clean and free from water, scale, dirt, oil residues etc. to reveal corrosion, deformation, fractures, damages or other structural deterioration. However, those areas of structure whose renewal has already been decided by the owner need only be cleaned and de-scaled to the extent necessary to determine the limits of renewed areas.

1.6.3 Sufficient illumination is to be provided.

1.6.4 Means are to be provided to enable the Surveyor to examine the structure in a safe and practical way.

1.6.5 For surveys, including close-up survey where applicable, in cargo spaces and ballast tanks, one or more of the following means of access, is to be provided:

(a) Permanent staging and passages through structures.
(b) Temporary staging and passages through structures.
(c) Lifts and movable platforms.
(d) Boats or rafts.
(e) Other equivalent means.

1.6.6 Survey at sea or anchorage may be undertaken when the Surveyor is fully satisfied with the necessary assistance from the personnel onboard and provided the following conditions and limitations are met:

(a) Surveys of tanks by means of boats or rafts is at the sole discretion of the attending Surveyor, who is to take into account the safety arrangements provided, including weather forecasting and ship response in reasonable sea conditions. Appropriate life jackets are to be available for all participants. The boats or rafts are to have satisfactory residual buoyancy and stability even if one chamber is ruptured. A safety checklist is also to be provided. An oxygen-meter, breathing apparatus, lifeline and whistles are to be at hand during the survey. For oil supply ships an explosimeter is also to be provided.
(b) A communication system is to be arranged between the survey party in the tank and the responsible officer on deck. This system must include the personnel in charge of ballast pump handling if boats or rafts are to be used.
(c) Surveys of tanks by means of boats or rafts will only be permitted for the under deck areas of tanks when the coating of the under deck structure is in GOOD condition and there is no evidence of wastage. The only exception to this, at the discretion of the Surveyor, is where the depth of under deck web plating is 1.5 m or less. Alternatively, rafting may be used if a permanent means of access is provided in each bay to allow safe entry and exit. This means of access is to be direct from deck via a vertical ladder and a small platform fitted approximately 2 m below deck. Where these conditions are not met, then the under deck area will require to be staged for survey.

1.7 Repairs

1.7.1 Any damage in association with wastage over the allowable limit (including buckling, grooving, detachment or fracture), or extensive areas of wastage over the allowable limits, which affects or, in the opinion of the Surveyor, will affect the ship's structural, watertight or weathertight integrity, is to be promptly and thoroughly repaired. Areas to be considered include, (where fitted):

(a) Side shell frames, their end attachments or adjacent shell plating;
(b) deck structure and deck plating;
(c) bottom structure and bottom plating;
(d) side structure and side plating;
(e) inner bottom structure and inner bottom plating;
(f) inner side structure and inner side plating;
(g) watertight or oiltight bulkheads;
(h) hatch covers or hatch coamings.

For locations where adequate repair facilities are not available, consideration may be given to allow the ship to proceed directly to a repair facility. This may require discharging the cargo and/or temporary repairs for the intended voyage.

1.7.2 Additionally, when a survey results in the identification of substantial corrosion or structural defects, either of which, in the opinion of the Surveyor, will impair the ship's fitness for continued service, remedial measures are to be implemented before the ship continues in service.

1.8 Thickness measurement at surveys

1.8.1 This Section is applicable to the thickness measurement of the hull structure where required by Sections 2, 3, 5, and 6.

1.8.2 Prior to the commencement of the survey, a planning meeting is to be held between the attending Surveyor(s), the Owner/Navy's representative and the thickness measurement firm's representative, so as to ensure the safe and efficient execution of the surveys and thickness measurements to be carried out onboard.

1.8.3 Thickness measurements are normally to be by means of ultrasonic test equipment and are to be carried out by a company qualified as Grade 1 or Grade 2 according to Lloyd's Register's Approval for Thickness Measurement of Hull Structures, or by a suitably qualified Surveyor.

1.8.4 The degree of supervision or check testing by the Surveyor is dependent upon the grade of approval extended to the company carrying out the thickness measurements.

(a) The work of companies having Grade 1 approval is subject to check testing by the Surveyor.
(b) Thickness measurements by companies having Grade 2 approval are to be carried out with the Surveyor substantially in attendance.

1.8.5 The Surveyor may require measuring the thickness of the material in any portion of the structure where signs of wastage are evident or wastage is normally found. Any parts of the structure which are found defective or excessively reduced in scantlings are to be made good by materials of the approved scantlings and quality. Attention is to be given to the structure in way of discontinuities.

1.8.6 The Surveyor may extend the scope of thickness measurement if deemed necessary.

1.8.7 Where it is required as part of the survey to carry out thickness measurements for the structural areas subject to Close-up Survey, then these measurements are to be carried out simultaneously with the Close-up Survey.

1.8.8 Thickness measurements are to be taken at the forward and aft areas of shell plates. A number of readings should be taken in a local area, and averaged to provide the recorded reading. The extent of local substantial corrosion of plates is to be established by intensive measurement in the affected areas. Where measured plates are to be renewed, the thicknesses of adjacent plates in the same strake are to be reported.

1.8.9 Thickness measurement is normally carried out by approved companies who are required to report their findings to LR.

1.8.10 A report is to be prepared by the approved company carrying out the thickness measurements. The report is to give the location of measurement, the thickness measured as well as the corresponding original thickness. The report is to give the date when measurement was carried out, the type of measuring equipment, names of personnel and their qualifications and is to be signed by the operator and supervisor.

1.8.11 The thickness measurement report is to be verified and signed by the Surveyor and countersigned by an authorising Surveyor.

■ *Section 2*
Annual Surveys – Hull, machinery and optional requirements

2.2 Hull

2.2.1 The Surveyor is to be satisfied regarding:

(a) The efficient condition of doors, hatchways and lifts on upper and superstructure decks, weather deck plating and air pipes, exposed casings, deckhouses, superstructure bulkheads, side, bow and stern doors, windows, side scuttles and deadlights, guard rails, life-lines, ladders, pressure relief plates and other openings, together with all closing appliances and flame screens. In addition, the Surveyor is to externally examine all air pipe heads installed on exposed decks.

(b) The efficient operating condition of mechanically operated hatch covers including stowage, fit, securing, locking, sealing and operational testing of hydraulic power components.

(c) The efficient condition of scuppers and sanitary discharges (so far as is practicable); valves on discharge lines (so far as is practicable) and their controls; guard rails and bulwarks.

~~*2.2.9* The Surveyor is to carry out a Close-up Survey and thickness measurement of structure identified at the previous Special Survey as having substantial corrosion.~~

2.2.9 The Surveyor is to carry out an examination and thickness measurement of structure identified at the previous Special Survey or Intermediate Survey as having substantial corrosion.

2.3 Machinery

2.3.10 The electrical equipment and cabling forming the main and emergency electrical installations are to be generally examined under operating conditions as far as is practicable. Particular checks are to be made on the integrity of electrical enclosure and cleanliness of switchboards and bus bars. The satisfactory operation of the main and emergency sources of power and electrical services essential for safety in an emergency is to be verified; where the sources of power are automatically controlled they should be tested in the automatic mode. Bonding straps for the control of static electricity and earthing arrangements are to be examined where fitted.

~~*2.3.11* Bonding straps for the control of static electricity and earthing arrangements are to be examined where fitted.~~

2.3.11 The electrical installation in areas deemed dangerous, such as magazine spaces and spaces where low flash point oils are stored and handled and compartments adjacent to such spaces, is to be examined in order to verify that it is of the correct type, is in good condition and has been properly maintained.

2.3.15 Dead ship starting arrangements for bringing machinery into operation without external aid are to be tested to the Surveyor's satisfaction.

■ *Section 4*
Docking Surveys and In-water Surveys

4.2 Docking Surveys

~~*4.2.2* Attention is to be given to parts of the external hull structure particularly liable to structural deterioration from causes such as high stresses, chafing and lying on the ground, and to areas of structural discontinuity.~~

4.2.2 The external shell plating is to be examined for excessive corrosion, structural deterioration from causes such as high stresses, chaffing or contact with the ground, to areas of structural discontinuity and for undue unfairness or buckling. Special attention is to be given to the connection between the bilge strakes and the bilge keels.

4.2.5 The sea connections and overboard discharge valves, their attachments to the hull and the gratings, at the sea inlets are to be examined. ~~References must be made to the C11(N) document carried on board.~~ Where applicable, pressure testing of the rudder may be required if deemed necessary by the Surveyor.

4.3 In-water Surveys

~~*4.3.1* The Committee will accept an In-water Survey between Special Surveys, as a Docking Survey, where suitable protection is applied to the underwater portion of the hull. If requested, an IWS record may be assigned on satisfactory completion of the survey, provided that the applicable requirements of the Rules are complied with.~~

4.3.1 The Committee will accept an In-water Survey between Special Surveys, as a Docking Survey, where suitable protection is applied to the underwater portion of the hull. If requested, the ***IWS** notation may be assigned on satisfactory completion of the survey, provided that the applicable requirements of the Rules are complied with.

~~*4.3.4 The In-water Survey is to be carried out at agreed geographical locations under the surveillance of a Surveyor to LR, with the ship in sheltered waters. The in-water visibility is to be good and the hull below the waterline is to be clean. The Surveyor is to be satisfied that the method of pictorial presentation is satisfactory by use of CCTV. There is to be good two-way communication between the Surveyor and the diver.*~~

4.3.4 The In-water Survey is to be carried out at an agreed geographical location under the surveillance of a Surveyor to LR, with the ship in sheltered waters and with weak tidal streams and currents. The in-water visibility is to be good and the hull below the waterline is to be clean. The Surveyor is to be satisfied that the method of pictorial presentation is satisfactory by use of CCTV. There is to be good two-way communication between the Surveyor and the diver.

~~*4.3.5 Diving and In-water Survey operations are to be carried out by companies recognised by LR. Continued recognition by LR will be dependent on the standard of workmanship by the company being maintained to the satisfaction of LR's Surveyors.*~~

4.3.5 Prior to commencing the In-water Survey, the equipment and procedures for both observing and reporting the survey are to be agreed between the Owners, the Surveyor and the diving firm.

4.3.6 The In-water Survey is to be carried out by a qualified diver employed by the firm approved by LR.

~~*4.3.6*~~ *4.3.7* If the In-water Survey reveals damage or deterioration that requires early attention, the Surveyor may, in consultation with the Owner, require that the ship be dry-docked in order that a fuller survey can be undertaken and the necessary work carried out.

~~*4.3.7 Where a vessel has an IWS record, the condition of the high resistant paint is to be confirmed at each dry-docking in order that the IWS record can be maintained.*~~

4.3.8 Where a vessel has the ***IWS** notation, the condition of the high resistant paint is to be confirmed at each dry-docking in order that the ***IWS** notation can be maintained.

■ *Section 5*
Special Survey – Hull requirements

5.3 Examination and testing – General

~~*5.3.2 Double bottom compartments, peak tanks and all other integral tanks are to be tested by a head sufficient to give the maximum pressure that can be experienced in service. (It should be noted that 'Replenishment at Sea' has the potential of imposing greater pressures on tank boundaries than that normally met in service). Tanks may be tested afloat provided that their internal examination is also carried out afloat.*~~

5.3.2 Double bottom, deep, ballast, peak and other tanks assigned also for the carriage of salt water ballast, are to be tested with a head of liquid to the top of air pipes or to the top of hatches for ballast/cargo holds. Boundaries of oil fuel, lubricating oil and fresh water tanks are to be tested with a head of liquid to the maximum filling level of the tank. Tank testing of oil fuel, lubricating oil and fresh water tanks may be specially considered based upon a satisfactory external examination of the tank boundaries, and a confirmation from the Commanding Officer stating that the pressure testing has been carried out according to the requirements with satisfactory results.

5.3.9 The hand pumps, suctions, watertight doors, air and sounding pipes are to be examined. In addition, the Surveyor is to internally examine air pipe heads in accordance with the requirements of Table 3.5.3.

5.4 Examination and testing – Additional items for steel ships

~~*5.4.1 All integral tanks are generally to be internally examined. However, in certain circumstances the internal examination of lubricating oil, fresh water and oil fuel tanks may be waived. For the minimum extent of tank internal examination, see Table 3.5.2.*~~

5.4.1 The requirements for tank internal examination are given in Table 3.5.2.

Table 3.5.2 Tank internal examination requirements for steel ships

Tank	Special Survey I (Ship 6 years old)	Special Survey II (Ship 12 years old)	Special Survey III (Ship 18 years old)	Special Survey IV (Ship 24 years old)	All Subsequent Special Surveys
Peaks	All tanks	All tanks	All tanks	All tanks	All tanks
Salt water ballast	All tanks	All tanks	All tanks	All tanks	All tanks
Lubricating oil	None	None	~~*See* Note 1~~ None	*See* Notes 1 and 2 One tank	~~All tanks~~ One tank
Fresh water	None	~~*See* Note 1~~ One tank	~~*See* Notes 1 and 2~~ All tanks	*See* Notes 1 and 2 All tanks	All tanks
Oil fuel - in way of (i) Machinery space	None	~~*See* Note 1~~ None	~~*See* Notes 1 and 2~~ One tank	~~*See* Notes 1 and 2~~ One tank	~~All tanks~~ One tank
(ii) Supply (Replenishment) Oil Area	None	One tank	Two tanks - *see* Note 3	50% of tanks - *see* Notes 3 & 4	50% of tanks - see Notes 3 & 4
Oil Fuel (water compensated)	~~*See* Note 1~~ All tanks	All tanks	All tanks	All tanks	All tanks
Sanitary	All tanks	All tanks	All tanks	All tanks	All tanks

NOTES
1. The above requirements apply to integral tanks only.
2. Where a selected number of tanks are examined, then different tanks are to be examined at each Special Survey on a rotational basis.
3. To include one deep tank, if any.
4. Where 50% of tanks are to be examined, a minimum of two tanks are required to be examined depending upon the overall number of tanks.

~~1. Tanks (excluding peak tanks) used exclusively for oil fuel, fresh water, oil fuel and water ballast, avcat or lubricating oil need not all be examined internally provided that the Surveyor is satisfied with the condition, after both external examination and testing, and from an internal examination of two representative tanks. (These representative tanks should change from survey to survey).~~

~~2.~~ 5. When examining tanks internally the Surveyor is to verify that striking plates or other additional reinforcement is fitted under sounding pipes. In the case of tanks only with remote gauging facilities, the satisfactory operation of the gauges is to be confirmed.

~~3.~~ 6. Particular care must be taken in examining structure under suctions.

~~4.~~ 7. Where testing is required, a functional test may be acceptable at the Surveyor's discretion.

Table 3.5.3 Airpipe head internal examination requirements

Special Survey I (Ships 6 years old)	Special Survey II (Ships 12 years old)	Special Survey III (Ships 18 years old) and subsequent
(1) Two air pipe heads (one port and one starboard) on exposed decks in the forward 0,25*L*. (*See* Notes 1 to 5)	(1) All air pipe heads on exposed decks in the forward 0,25*L*. (*See* Notes 1 to 5)	All air pipe heads on exposed decks. (*See* Notes 1 to 6)
(2) Two air pipe heads (one port and one starboard) on the exposed decks, serving spaces aft of 0,25*L*. (*See* Notes 1 to 5)	(2) At least 20% of air pipe heads on exposed decks, serving spaces aft of 0,25*L*. (*See* Notes 1 to 5)	

NOTES
1. Air pipe heads serving ballast tanks are to be selected where available.
2. The Surveyor is to select which air pipe heads are to be examined.
3. Where considered necessary by the Surveyor as a result of the examinations, the extent of examinations may be extended to include other air pipe heads on exposed decks.
4. Where the inner parts of the air pipe head cannot be properly examined due to its design, it is to be removed in order to allow an internal examination.
5. Particular attention is to be given to the condition of the zinc coating in heads constructed from galvanised steel.
6. Exemption may be considered for air pipe heads where there is documented evidence of their replacement within the previous six years.

■ *Section 6*
Special Survey – Thickness measurement requirements for steel ships

6.1 General

~~*6.1.1* The Surveyor may require measurements of thickness of the material to be taken in any portion of the structure where signs of wastage are evident or wastage is normally found. Any parts of the structure which are found defective or excessively reduced in scantlings are to be made good by materials of the approved scantlings and quality. Particular attention is to be given to the structure in way of discontinuities.~~

~~*6.1.2* Thickness measurements, as required by Table 3.6.1, are to be carried out in accordance with the following requirements.~~

~~*6.1.3* Measurements are to be taken at the forward and aft areas of shell plates. A number of readings should be taken in a local area, and averaged to provide the recorded reading. The extent of local substantial corrosion of plates is to be established by intensive measurement in the affected areas. Where measured plates are to be renewed, the thicknesses of adjacent plates in the same strake are to be reported.~~

~~*6.1.4* Thickness measurements are normally to be by means of ultrasonic test equipment and are to be carried out by a company qualified as Grade 1 or Grade 2 according to Lloyd's Register's (hereinafter referred to as 'LR') Approval for Thickness Measurement of Hull Structures, or by a suitably qualified Surveyor.~~

~~*6.1.5* The degree of supervision or check testing by the Surveyor is dependent upon the grade of approval extended to the company carrying out the thickness measurements.~~

~~(a) The work of companies having Grade 1 approval is subject to check testing by the Surveyor.~~

~~(b) Thickness measurements by companies having Grade 2 approval are to be carried out with the Surveyor substantially in attendance.~~

6.1.1 Thickness measurement requirements for steel ships are stated in Tables 3.6.1 and 3.6.2. *See also* 1.8.

~~6.1.6~~ 6.1.2 Thickness measurements may be carried out in association with the fifth Annual Survey.

6.1.3 In areas where substantial corrosion, as defined in 1.5, has been noted, then additional measurements are to be carried out, as applicable, in accordance with Table 3.6.2 to determine the full extent of the corrosion pattern.

6.1.4 Where substantial corrosion is identified and not rectified, this will be subject to re-examination and gauging as necessary at Annual and Intermediate Surveys.

6.1.5 At each Special Survey, thickness measurements are to be taken in way of critical areas, as considered necessary by the Surveyor. Critical areas are to include locations throughout the ship that show substantial corrosion and/or are considered prone to rapid wastage.

~~6.1.7~~ 6.1.6 The Surveyor may extend the scope of thickness measurement if deemed necessary.

Table 3.6.2 Thickness measurement - Additional requirements in way of structure identified with substantial corrosion

Structural member	Extent of measurement	Pattern of measurement
Plating	Suspect areas and adjacent plates	5 point pattern over 1 m^2
Stiffeners	Suspect areas	3 measurements each in line across web and flange

■ *Section 13*
Screwshafts, tube shafts and propellers

13.1 Frequency of surveys

~~*13.1.6* Directional propeller and podded drive units for main propulsion purposes are to be surveyed at intervals not exceeding six years.~~

13.1.6 Directional propeller and podded propulsion units for main propulsion purposes are to be surveyed at intervals not exceeding six years.

13.2 Normal surveys

~~*13.2.2* Directional propeller and podded drive units are to be dismantled for examination of the propellers, shafts, gearing, control, electrical and monitoring equipment.~~

13.2.2 Directional propeller and podded propulsion units are to be dismantled for examination of the propellers, shafts, gearing, and control and electrical gear.

13.2.5 Podded propulsion unit screwshaft roller bearings are to be renewed when the residual calculated life at the maximum continuous rating at time of survey, no longer exceeds the survey interval. *See* Vol 2, Pt 4, Ch 4,6.3.8.

Section 16
Classification of ships not built under LR survey

16.3 Machinery

16.3.1 To facilitate the survey, plans of the following items (plans of piping are to be diagrammatic), together with the particulars of the materials used in the construction of the boilers, air receivers and important forgings are to be furnished:

General piping system arrangements, including air and sounding pipes (Builder's plan).

Bilge, dewatering, ballast and oil fuel piping arrangements including the capacities of the pumps on bilge service.

Arrangement and dimensions of main steam pipes.

Arrangement of oil fuel pipes and fittings at settling and service tanks.

Arrangement of oil fuel piping in connection with oil burning installations.

Oil fuel overflow systems, where these are fitted.

Arrangement of boiler feed systems.

Oil fuel settling, service and other oil fuel tanks not forming part of the ship's structure.

Boilers, superheaters and economizers.

Air receivers.

Crank, thrust, intermediate and screw shafting.

Clutch and reversing gear with methods of control.

Reduction gearing.

Propeller (including spare propeller if supplied)

Electrical circuits, as listed in Vol 2, Pt 10, Ch 1,1.2.2, 1.2.3 and 1.2.4.

Arrangement of compressed air systems for main and auxiliary services.

Arrangement of lubricating oil, hydraulic oil, thermal oil and other systems containing flammable liquids.

Arrangements of cooling water systems for main and auxiliary services.

Steering gear system and piping arrangements together with manufacturer, model and rating information.

Aircraft/helicopter and vehicle fuel storage and distribution systems.

Chilled water systems.

High pressure sea water systems.

Heating and ventilation systems.

Made and fresh water systems.

Hydraulic power actuating systems.

Propulsion engine details including manufacturer, model and rating information.

Electrical generator engine details including manufacturer, model and rating information.

For **UMS** notation the following plans are to be submitted for appraisal:

- Fire alarm system.
- Instrumentation list.
- Plans for systematic maintenance and function testing.
- Test schedule.

Where an Ice Class notation is required the following plans are to be submitted for appraisal:

- Main propulsion line shafting.
- Reduction gears.
- Propeller.
- Details of any clutch system in the propulsion line.

Replenishment at sea arrangements where a **RAS** notation is requested.

Section 17
Classification of ships built under survey to LR Classification Rules and Regulations other than LR Naval Ship Rules and Regulations

17.1 General

17.1.1 When Naval ship classification is desired for an existing ship built under the supervision of LR's Surveyors to Classification Rules and Regulations other than LR Naval Ship Rules and Regulations, application should be made in writing.

17.2 Hull and equipment

17.2.1 Plans showing the features not covered by merchant classification are to be submitted. These may include the following which should be addressed for strength and, where appropriate, stiffness aspects:

- Masts.
- Weapon system seats.
- RAS seats, landing areas.
- Aircraft landing guides.
- Towing points.
- Military loads.
- Beaching.
- Material grades.
- Watertight integrity.
- Strength of watertight structure.

If plans cannot be obtained or prepared by the Owner, facilities are to be given for LR's Surveyor to obtain the necessary information from the ship.

17.3 Machinery

~~*17.3.1* To facilitate the survey of systems not covered by the other Classification Rules with which the ship is classed, the following details are to be furnished:~~

- ~~Aircraft/helicopter and vehicle fuel storage and distribution systems.~~
- ~~Chilled water systems.~~
- ~~High pressure sea water systems.~~
- ~~High and low pressure compressed air systems.~~
- ~~RAS arrangements.~~

~~*17.3.2* Details additional to those detailed in 16.3.1 are not to be submitted unless the machinery or installation is of a novel or special character affecting classification.~~

~~*17.3.3* The whole of the machinery, including essential controls, is to be tested under working conditions to the Surveyor's satisfaction.~~

~~*17.3.4* Relevant reports are to be prepared by the Surveyors.~~

17.3.1 To facilitate the assessment and survey of systems not covered by the other Classification Rules with which the ship is classed, the following information with supporting plans is to be submitted to LR:

(a) Aircraft/helicopter and vehicle fuel storage and distribution systems.
(b) Chilled water systems.
(c) High pressure sea water systems.
(d) High and low pressure compressed air systems.
(e) Hydraulic power actuating systems.
(f) Made and fresh water systems.
(g) Heating, ventilation and cooling arrangements.
(f) Replenishment at sea arrangements where a **RAS** notation is requested.

17.3.2 Details additional to those stated in 17.3.1 are not to be submitted unless the machinery or installation is of a novel or special character affecting Mobility, Ship Type or Ancillary category systems for Machinery Naval Classification.

17.3.3 The whole of the machinery, including essential controls and safety arrangements, is to be tested to an agreed test plan under working conditions to the Surveyor's satisfaction.

17.3.4 Relevant reports on the submitted information and testing are to be prepared by the Surveyors.

Volume 1, Part 3, Chapter 2
Ship Design

(Effective date 1 January 2005)

■ *Section 5*
Fore and aft end arrangements

5.3 Minimum bow height and extent of forecastle

5.3.2 All sea-going ships are to be fitted with forecastles, or increased sheer on the upper deck or equivalent, such that the distance from the waterline design draught to the top of the exposed deck at side at the F.P. is not less than:

~~For ships less than 250 m in length:~~

$$~~H_b = 56L_R\left(1 - \frac{L_R}{500}\right)\left(\frac{1,36}{C_b + 0,68}\right)~~ \text{mm}$$

~~For ships 250 m and above in length:~~

$$~~H_b = 7000\left(\frac{1,36}{C_b + 0,68}\right)~~ \text{mm}$$

~~where~~

- ~~C_b = block coefficient which is not to be less than 0,68 for this calculation~~
- ~~H_b = minimum bow height, in mm~~
- ~~L_R = Rule length.~~

$$H_b = \left(6075\left(\frac{L_R}{100}\right) - 1875\left(\frac{L_R}{100}\right)^2 + 200\left(\frac{L_R}{100}\right)^3\right) \times \left(2,08 + 0,609C_b - 1,603C_{wf} - 0,0129\left(\frac{L_R}{d_1}\right)\right)$$

where

- C_b = block coefficient, not to be less than 0,68
- L_R = Rule Length, in m
- H_b = minimum bow height, in mm
- d_1 = draught at 85% of the depth, *D, see* Vol 1, Pt 3, Ch 1,5.2.10.
- C_{wf} = waterplane area coefficient forward of midships $A_{wf} / \{(L_R/2) \times B\}$
- B = moulded breadth , in m
- A_{wf} = is the forward waterplane area at draught d_1, in m^2.

Volume 1, Part 3, Chapter 3
Ship Control Systems

(Effective date 1 January 2005)

■ *Section 2*
Rudders

2.24 Bolted couplings

2.24.3 ~~For rudders with horizontal coupling arrangements, where the upper flange is welded to the rudder stock, a full penetration weld is required and its integrity is to be confirmed by non-destructive examination. Such rudder stocks are to be subjected to a furnace post-weld heat treatment (PWHT) after completion of all welding operations. For carbon or carbon manganese steels, the PWHT temperature is not to be less than 600°C.~~ For rudders with horizontal coupling arrangements the rudder stock should be forged when the stock diameter exceeds 350 mm. Where the stock diameter does not exceed 350 mm the rudder stock may be either forged or fabricated. Where the upper flange is welded to the rudder stock, a full penetration weld is required and its integrity is to be confirmed by non-destructive examination. The flange material is to be from the same welding materials group as the stock. Such rudder stocks are to be subjected to a furnace post-weld heat treatment (PWHT) after completion of all welding operations. For carbon or carbon manganese steels, the PWHT temperature is not to be less than 600°C.

2.24.4 For a spade rudder the fillet radius between the rudder stock and the flange is to conform to the requirements of Fig. 3.2.8. Where space permits between the upper face of the flange and the lower rudder stock bearing, it is preferable to use a compound fillet design of the parabolic or Morgenbrod form having similar dimensions to those of Fig. 3.2.8. Alternative arrangements will be specially considered.

Existing paragraphs 2.24.4 and 2.24.5 are to be renumbered 2.24.5 and 2.24.6

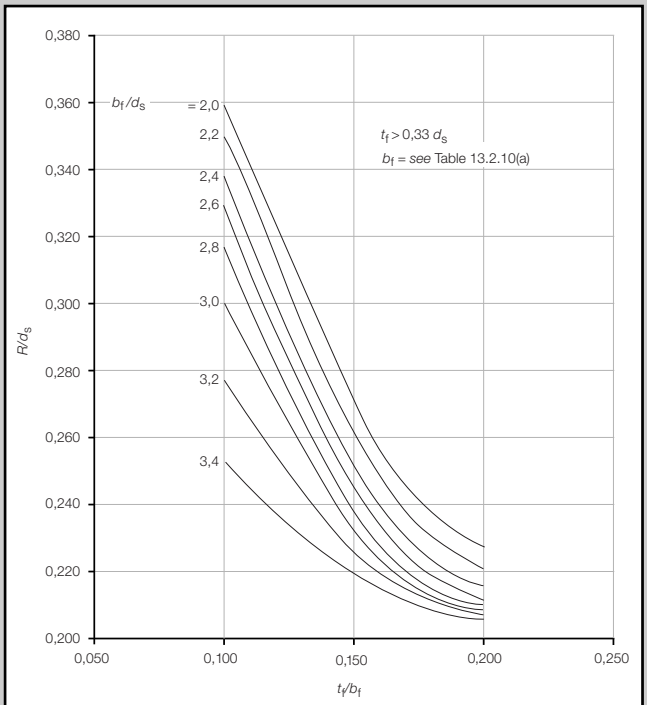


Fig. 3.2.8 Rudder stock horizontal flange fillet radius for spade rudders

Table 3.2.10 Rudder couplings to stock (*continued*)

Symbols

n = number of bolts in coupling
d_b = diameter of coupling bolts, in mm
d_s, d_{su} = rudder stock diameters as defined in 2.15 and 2.14 respectively
m = first moment of area of bolts about centre of coupling, in cm^3
t_f = thickness of coupling flange, in mm
w_f = width of flange material outside the bolt holes, in mm
K_o = rudder stock material factor *see* 1.4.3
h = vertical distance between the centre of pressure and the centre point of the palm radius, R, in metres, *see* Fig. 3.2.7(a)
R =palm radius between rudder stock and connected flange not smaller than $\frac{d_s}{10}$ in mm
t_f = minimum thickness of coupling flange, in mm
t_{fa} = as built flange thickness, in mm
α_{max} = maximum allowable stress concentration factor
$\alpha_{as\ built}$ = stress concentration factor for as built scantlings

$$= \frac{0{,}73}{\sqrt{\left(\frac{R}{d_s}\right)}}$$

θ_t = taper of conical coupling, on the diameter, e.g.:

$\theta_t = \frac{1}{15} = 0{,}067$

F_R = rudder force kN
l_t = length of taper, in mm

σ_{GM} = required mean grip stress, in N/mm^2
w = corresponding push-up of rudder stock, in mm
P_u, P_o = corresponding push-up, pull-off loads respectively, in N
σ_o = minimum yield stress of stock and gudgeon material, in N/mm^2. σ_o is not to be taken greater than 70 per cent of the ultimate tensile strength
P_R = effective weight of rudder, in N
d_{STM} = mean diameter of coupling taper, in mm
d_{ST} = diameter of coupling taper at any position, in mm
d_{GHM} = mean external diameter of gudgeon housing, in mm
d_{GH} = external diameter of gudgeon housing at any position, in mm
$f_m = \frac{d_{STM}}{d_{GHM}}$
$f = \frac{d_{ST}}{d_{GH}}$
Q_R = maximum turning moment applied to stock, and is to be taken as the greater of:
(a) As determined from 2.12.
(b) The torque generated by the steering gear at the maximum working pressure
b_f = breadth of the flange, in mm

K_1, K_2, K_3 = constants depending on the type of assembly adopted as follows:

		K_1	K_2	K_3
Oil injection method	with key	15	0,0064	0,025
	without key	15	0,0036	0,025
Dry fit method	with key	12	0,0128	0,170
	without key	12	0,0072	0,170

NOTES
1. Where materials vary for individual components, scantling calculations for such components are to be based on d_s for the relevant material.
2. For spade rudders with horizontal couplings, t_f is not to be less than ~~0.25~~ 0.33 d_s. The mating plate on the rudder is to have the same thickness as the flange on the stock d_s.
3. For a twin spade rudder arrangement with single screw where the rudders are within the slipstream of the propeller:
(a) the thickness of the palm is not to be less than 0.35 d_s .
(b) where the stock is welded to the palm plate, the stock diameter, d_S is to be increased by 14%.

~~3~~ 4. This requirement is applicable only for spade rudders with horizontal couplings, *see* Fig. 3.2.7.

Volume 1, Part 3, Chapter 4
Closing Arrangements and Outfit

(Effective date 1 January 2005)

■ *Section 4*
Side lights and windows

4.1 General

4.1.1 Side scuttles are defined as being round or oval openings with an area not exceeding 0,16 m^2.

4.1.2 Windows are defined as being rectangular openings generally, and round or oval openings with an area exceeding 0,16 m^2.

Existing paragraphs 4.1.1 to 4.1.14 are to be renumbered 4.1.3 to 4.1.16.

■ *Section 5*
Ventilators

5.5 Closing appliances

5.5.1 All ventilator openings are to be provided with efficient weathertight closing appliances of steel or other equivalent material unless the height of the coaming is greater than 2,5 m above the weather deck or 5 m on exposed deck immediately above the design waterline, e.g. quarter decks and well decks.

5.6 Machinery spaces

5.6.1 In general, ventilators necessary to continuously supply the machinery space are to have coamings of sufficient height to comply with 5.5.1 without having to fit weathertight closing appliances. Ventilators to emergency generator rooms are to be so positioned that closing appliances are not required.

5.6.2 Where due to ship size and arrangement this is not practicable, lesser heights for machinery space ventilator coamings fitted with weathertight closing appliances may be permitted by the Naval Authority in combination with other suitable arrangements to ensure uninterrupted, adequate supply of ventilation to these spaces.

■ *Section 6*
Air pipes

6.3 Closing appliances

6.3.2 Closing appliances are to be of an approved automatic type. ~~when, with the ship at its design draught, the openings are immersed at an angle of heel of ?df or, the angle of down flooding if this is less than ?df . *See also* Ch2,1.3. The Naval Authority may prohibit openings which are immersed below the ?df angle.~~

~~*6.3.3* Where the closing appliances are not of an automatic type, provision is to be made for relieving vacuum when the tanks are being pumped out.~~

■ *Section 8*
Bulwarks, guard rails and other means for the protection of crew and embarked personnel

8.1 General requirements

8.1.1 Bulwarks or guard rails are to be provided at the boundaries of exposed decks. Bulwarks or guard rails are to be not less than 1,0 m in height measured above sheathing, and are to be constructed as required by ~~8.2~~ this Section. Consideration will be given to cases where this height would interfere with the normal operation of the ship. Guard rails provided around aircraft operating areas may be of the type which drop outwards with nets to the satisfaction of the Naval Authority, provided access is restricted to essential personnel. Where bulwarks or rails are undesirable e.g. for radar signature purposes, alternative equivalent arrangements will require to be provided.

8.1.3 Guard rails fitted on superstructure and exposed decks are to have at least three courses. The opening below the lowest course of guard rails is not to exceed 230 mm. The other courses are to be spaced not more than 380 mm apart. In the case of ships with rounded gunwales, the guard rail supports are to be placed on the flat of the deck. In other locations, guard rails with at least two courses are to be fitted.

8.1.4 Guard rails are to be fitted with fixed, removable or hinged stanchions fitted no more than 1,5 m apart. Removable or hinged stanchions shall be capable of being locked in the upright position.

8.1.5 At least every third stanchion is to be supported by a stay.

~~*8.1.5*~ *8.1.6* Where necessary for the normal operation of the ship, steel wire ropes may be accepted in lieu of guard rails. Wires are to be made taut by means of turnbuckles. Chains are only permitted in short lengths in way of access openings.

Existing paragraph 8.1.4. is to be renumbered 8.1.7 and existing paragraph 8.1.6. is to be renumbered 8.1.8.

8.3 Freeing arrangements

~~*8.3.12* Adequate provision is to be made for freeing water from superstructures which are open at either or both ends and from all other decks within open or partially open spaces in which water may be shipped and contained.~~

Existing paragraphs 8.3.13 to 8.3.15 are to be renumbered 8.3.12 to 8.3.14.

~~*8.3.16*~~ *8.3.15* Where shutters are fitted, the pins or bearings are to be of a non-corrodible material, with ample clearance to prevent jamming. The hinges are to be within the upper third of the port. Shutters are not to be fitted with securing appliances.

Existing paragraph 8.3.17 is to be renumbered 8.3.16.

8.3.17 In ships having superstructures which are open at either or both ends to wells formed by bulwarks on the open deck, adequate provision for freeing the open spaces are to be provided as follows:

The freeing port area, A_w for the open well:

$$A_w = (0{,}07 l_w + A_c)(S_c)\left(\frac{0{,}5 h_s}{h_w}\right)$$

The freeing port area, A_s for the open superstructure:

$$A_S = (0{,}07 l_t)(S_c)\left(\frac{b_o}{l_t}\left(1 - \left(\frac{l_w}{l_t}\right)^2\right)\left(\frac{0{,}5 h_s}{h_w}\right)\right)$$

where

l_w = the length of the open deck enclosed by bulwarks, in metres

l_s = the length of the common space within the open superstructure, in metres

l_t = $l_w + l_s$ but if 20 m or less then the freeing area is to be calculated in accordance with 8.3.3(a)

S_c = sheer correction factor, maximum 1,5 as defined in 8.3.8

b_o = breadth of openings in the end bulkhead of the enclosed superstructure, in metres

h_w = distance of the well deck above the freeboard deck, in metres

h_s = one standard superstructure height

h_b = actual height of the bulwark, in metres.

A_c = bulwark height correction factor taken as;

= 0 for bulwarks between 0,9 and 1,2 m in height

= $0{,}004\, l_w \left(\frac{(h_b - 1{,}2)}{1{,}0}\right)$ m^2

for bulwarks of height greater than 1,2 m, and

= $0{,}004\, l_w \left(\frac{(h_b - 0{,}9)}{1{,}0}\right)$ m^2

for bulwarks of height less than 0,9 m

Volume 1, Part 3, Chapter 5
Anchoring, Mooring, Towing, Berthing, Launching, Recovery and Docking

(Effective date 1 January 2005)

■ *Section 2*
Equipment Number

2.1 Equipment Number calculation

[Part only shown]

A = area, in m^2, in profile view, of the hull, superstructures, houses, masts, etc. above the design draught which are within the Rule length of the vessel and also have a breadth greater than $B/4$. *See also* 2.1.2. ~~and 2.1.3~~

~~*2.1.2* In the calculation of At, if a house having a breadth greater than B/4 is above a house with a breadth of B/4 or less, then the wide house is to be included, but the narrow house ignored.~~

~~*2.1.3*~~ *2.1.2* Screens and bulwarks more than 1,5 m in height are to be regarded as parts of houses when determining *A* ~~and At~~. Where a screen or bulwark is of varying height, the portion to be included is to be that length the height of which exceeds 1,5 m.

~~*2.1.4*~~ *2.1.3* For ships which have a complex above water transverse profile due to the presence of large plated masts, mast trees, large radar equipment, etc., the equipment number may need to be specially considered.

■ ~~*Section 4*~~
~~Ship type factors~~

~~4.1 General~~

~~*4.1.1* The Equipment Numbers derived from 2.1 are to be corrected by the ship type factors indicated in this Section.~~

~~4.2 Ship type factors~~

~~*4.2.1* NS1 and NS2. Ship type factor k_p = 1,15.~~

~~*4.2.2* NS3. Ship type factor k_p = 1,0.~~

Existing Sections 5 to 11 are to be renumbered Sections 4 to 10.

■ *Section ~~7~~6*
Mooring ropes

~~7.4~~ 6.4 Bollards, fairleads and bull rings

~~7.4.9~~ 6.4.9 The stresses in shipboard fittings associated with mooring are not to exceed ~~those given in Table 5.8.2~~ the specified minimum yield stress of the material in bending and 60 per cent of the specified minimum yield stress of the material in shear considering the design load defined in ~~7.4.5~~ 6.4.5.

■ *Section ~~8~~ 7*
Towing Arrangements

Table 5.7.1 Equipment – Minimum length and breaking strength of towlines

Equipment number		Equipment Letter	Towline	
Exceeding	Not Exceeding		Minimum length, in metres	Minimum strength, in kN
50	70	A	180	98
70	90	B	180	98
90	110	C	180	98
110	130	D	180	98
130	150	E	180	98
150	175	F	180	98
175	205	G	180	112
205	240	H	180	129
240	280	I	180	150
280	320	J	180	174
320	360	K	180	207
360	400	L	180	224
400	450	M	180	250
450	500	N	180	277
500	550	O	190	306
550	600	P	190	338
600	660	Q	190	370
660	720	R	190	406
720	780	S	190	441
780	840	T	190	479
840	910	U	190	518
910	980	V	190	559
980	1060	W	200	603
1060	1140	X	200	647
1140	1220	Y	200	691
1220	1300	Z	200	738
1300	1390	A†	200	786
1390	1480	B†	200	836
1480	1570	C†	220	888
1570	1670	D†	220	941
1670	1790	E†	220	1024
1790	1930	F†	220	1109
1930	2080	G†	220	1168
2080	1130	H†	240	1259
1130	1380	I†	240	1356
1380	2530	J†	240	1453
2530	2700	K†	260	1471
2700	2870	L†	260	1471
2870	3040	M†	260	1471
3040	3210	N†	280	1471
3210	3400	O†	280	1471
3400	3600	P†	280	1471
3600	3800	Q†	300	1471
3800	4000	R†	300	1471
4000	4000	S†	300	1471
4000	4400	T†	300	1471
4400	4600	U†	300	1471
4600	5000	V†	300	1471
5000	5200	W†	300	1471
5200	5500	X†	300	1471
5500	5500	Y†	300	1471
5500	5800	Z†	300	1471
5800	6100	A*	300	1471

Table 5.7.1 Equipment – Minimum length and breaking strength of towlines (cont.)

NOTE
1. Steel wire and fibre ropes used for towlines are to meet the requirements of the Rules for Materials, Vol 1, Pt 2, Ch 10,6 and 7 respectively.
2. Wire ropes for towlines used in association with mooring winches (on which rope is stored on the winch drum) are to be of suitable construction.

Table ~~5.8.15~~5.7.2 Design weather factors

Applicable notation	Wind speed coefficient, C_{mw}	Weather factor, K
TA1	0,0150	8
TA2	0,0129	7,2
TA3	0,0108	6,3

~~8.2~~ 7.2 Application

7.2.4 **TA1** This notation will be assigned when an appraisal has been made of the towing arrangements and strength performance of the supporting structures in accordance with the Rules. This notation recognises the most severe weather conditions, *see* Table 5.7.2 and 5.7.3.

7.2.5 **TA2** This notation will be assigned when an appraisal has been made of the towing arrangements and strength performance of the supporting structures in accordance with the Rules. This notation recognises weather conditions less severe than **TA1**, *see* Table 5.7.2 and 5.7.3.

7.2.6 **TA3** This notation will be assigned when an appraisal has been made of the towing arrangements and strength performance of the supporting structures in accordance with the Rules. This notation recognises the least severe weather conditions, *see* Table 5.7.2 and 5.7.3.

7.2.7 These three levels of towing arrangements in 7.2.4 to 7.2.6 recognise towing a ship of similar displacement at 6 knots in defined environmental conditions (*see* Table 5.7.3*)* and are appropriate for the weather conditions found in the equivalent service areas, i.e., **TA1** corresponds to the weather conditions found with service area notation **SA1**.

7.2.8 Where alternative requirements of the Navy or Naval Authority relating to the breaking load of the towing hawser required by Vol 1, Pt 3, Ch 5, 7.6.1 have been complied with, the ship will be entitled to the notation **TA(NS)**. These alternative requirements are to be clearly defined and referenced in the Certificate of Class. The load specified in the alternative is to replace the BL value given by the expression in 7.6.1.

7.2.9 Where the towline complies with the strength requirements of Table 5.7.1 as applicable to merchant ships for the related equipment number, the ship will be entitled to the assignment of the **TA(S)** notation. The breaking load specified in Table 5.7.1 is to replace the BL value given by the expression in 7.6.1.

7.2.10 Towing operations are to be in accordance with the towing, mooring and arrangements plan or equivalent information which is required to be placed on board. *See* 7.4.3.

Table 5.7.3 Environmental conditions

Beaufort Scale	Equivalent Mean Wind Speed (knots)	Wind Speed Coefficient, C_{mw}	Weather Factor, *K*
1-4	1-16	0,0025	3
5	17-21	0,0046	3,8
6	22-27	0,0067	4,7
7	28-33	0,0086	5,5
8	34-40	0,0108	6,3
9	41-47	0,0129	7,2
10+	48+	0,0150	8

~~8.5~~7.5 Towing Arrangements

~~*8.5.10*~~*7.5.10* The minimum length of the towing hawser is to be as given in Table 5.7.1. ~~the length of the summer load waterline plus 50m with a minimum length of 180 m.~~

~~8.6~~7.6 Strength requirements for towing arrangements

~~*8.6.1*~~*7.6.1* The actual ~~Maximum~~ Breaking Load (hereinafter referred to as ~~*M*~~*MBL*), as specified in the National or International Standard to which the towing hawser ~~in tonnes, of the towing hawser required to be~~ carried on board the ship is assessed, in Tonnes, is not to be less than that ~~can be~~ calculated below ~~as follows~~:

$$\text{~~}MBL\text{~~} = (0{,}03\Delta^{2/3} + (C_{mw}A_t))K$$

where

Δ = displacement, in tonnes, to the deep draft waterline

C_{mw} = wind speed coefficient, which is to be taken from Table ~~5.8.1~~ 5.7.2 for the relevant notation

K = weather factor, which is to be taken from Table ~~5.8.1~~ 5.7.2 for the relevant notation

A_t = transverse projected area, in m^2, of the hull and of all superstructures, houses, masts, etc. above the design draught

~~*8.6.2*~~ *7.6.2* The strength of other loose towing equipment e.g. links, shackles rings and chafing chain is to be determined on the basis of an applied load equal to 1,3 times the ~~*M*~~*MBL* of the towing hawser.

~~*8.6.3*~~ *7.6.3* The strength of strong points, bollards, fair leads and supporting structure is to be determined on the basis of an applied load equal to twice the ~~*M*~~*MBL* of the towing hawser.

~~*8.6.4*~~ *7.6.4* The stress in all loose and fixed towing equipment constructed of steel is not to exceed the specified minimum yield stress of the material in bending and 60 per cent of the specified minimum yield stress of the material in shear ~~that given in Table 5.8.2 considering the applied loads in 8.6.2 and 8.6.3.~~ Special consideration will be given if the vessel and/or towing equipment is not constructed of steel.

~~*8.6.10*~~ *7.6.10* Mooring winches included in the towing arrangement are to have an appropriate brake holding power to that of the ~~*M*~~*MBL* of the towing hawser. The holding capability should be calculated for the outermost towline layer on the winch drum at which towing will be performed.

~~**Table 5.8.2 Allowable stress**~~

	~~Bending stress, in N/mm^2~~	~~Shear stress, in N/mm^2~~
~~Allowable stress~~	~~$\frac{235}{k}$~~	~~$\frac{141}{k}$~~
~~where~~ ~~$k = 235 / \sigma_\theta$~~ ~~σ_θ = specified minimum yield strength of the material in N/mm^2~~		

Volume 1, Part 4, Chapter 1
Military Design

CORRIGENDUM

■ *Section 6*
Design guidance for magazines

6.10 Testing

6.10.1 Magazines are to be tested in accordance with the gas tight requirements of ~~Pt 6, Ch 2,5~~ Pt 6, Ch 6,6.8.

Volume 1, Part 4, Chapter 2
Military Load Specification

CORRIGENDA

■ *Section 2*
External blast

2.9 Structural assessment

2.9.7 The shear area of the stiffener web is not to be less than:

$$A_\tau = \frac{1}{100\tau_o}\left(\frac{f_{s1}\, f_{bz}\, Z_p\, \sigma_o}{1000 l_e} + f_{s2}\, P_{tm}\, l\, s\right) \text{cm}^2$$

where
Z_p, σ_o, l_e, l, s are given in 2.9.3
τ_o, P_{tm} are given in 2.9.4
f_{s1}, f_{s2} = shear load factors, given in Table 2.2.4
f_{bz} is given in 2.9.5.

Volume 1, Part 4, Chapter 3
Special Features

(Effective date 1 January 2005)

■ *Section 3*
Bow doors

3.1 Application

3.1.1 The requirements of this Section are applicable to the arrangement, strength and securing of bow doors, both the visor and the side opening type doors, and inner doors leading to a complete or long forward enclosed superstructure, or to a long non-enclosed superstructure which is fitted to attain minimum bow height equivalence.

3.3 Symbols and definitions

(Part only shown)
3.3.1 The symbols used in this Section are defined as follows:

~~A_x = area, in m^2, of the transverse vertical projection of the door between the levels of the bottom of the door and the upper deck or between the bottom of the door and the top of the door, whichever is the lesser, as shown in Fig. 3.3.2.~~

A_X = area, in m^2, of the transverse vertical projection of the bow door, between the bottom of the door and the top of the door or between the bottom of the door and the upper deck bulwark, or between the bottom of the door and the top of the door, including the bulwark, where it is part of the door, whichever is the lesser, *see* Fig. 3.3.2. Where the flare angle of the bulwark is at least 15 degrees less than the flare angle of the adjacent shell plating, the height from the bottom of the door may be measured to the upper deck or to the top of the door, whichever is lesser. In determining the height from the bottom of the door to the upper deck or to the top of the door, the bulwark is to be excluded.

~~A_y = area, in m^2, of the longitudinal vertical projection of the door between the levels of the bottom of the door and the upper deck or between the bottom of the door and the top of the door, whichever is the lesser~~

A_Y = area, in m^2, of the longitudinal vertical projection of the bow door, between the bottom of the door and the top of the upper deck bulwark, or between the bottom of the door and the top of the door, including the bulwark, where it is part of the door, whichever is the lesser, *see* Fig. 3.3.2. Where the flare angle of the bulwark is at least 15 degrees less than the flare angle of the adjacent shell plating, the height from the bottom of the door may be measured to the upper deck or to the top of the door, whichever is the lesser.

~~A_z = area of the horizontal projection of the door between the levels of the bottom of the door and the upper deck or between the bottom of the door and the top of the door, in m2, whichever is the lesser, as shown in Fig. 3.3.2.~~

A_Z = area, in m^2, of the horizontal projection of the bow door, between the bottom of the door and the top of the upper deck bulwark, or between the bottom of the door and the top of the door, including the bulwark, where it is part of the door, whichever is the lesser, *see* Fig. 3.3.2. Where the flare angle of the bulwark is at least 15 degrees less than the flare angle of the adjacent shell plating, the height from the bottom of the door may be measured to the upper deck or to the top of the door, whichever is the lesser.

3.6 Scantlings of bow doors

3.6.8 Scantlings of the primary members are generally to be supported by direct calculations in association with the external pressure given in 3.5.1 and permissible stresses given in 3.4.1. In general, formulae for simple beam theory may be applied to determine the bending stress. Members are to be considered to have simply supported end connections.

3.7 Scantlings of inner doors

3.7.1 Scantlings of the primary members are generally to be supported by direct calculations in association with ~~an~~ the external pressure given in 3.5.1 and permissible stresses given in 3.4.1. In general, formulae for simple beam theory may be applied to determine the bending stress. Members are to be considered to have simply supported end connections.

3.8 Securing and supporting of bow doors

3.8.12 All load transmitting elements in the design load path, from door through securing and supporting devices into the ship structure, including welded connections, are to be the same strength. These elements include pins, supporting brackets and back-up brackets. Where cut-outs are made in the supporting structure, the strength and stiffness will be specially considered.

3.9 Securing and locking arrangements

3.9.9 A drainage system is to be arranged in the area between bow door and ramp, ~~as well as in the area between the ramp and inner door where fitted~~ or where no ramp is fitted, between the bow door and inner door. The system is to be equipped with an audible and visual alarm function to the navigation bridge being set off when the ~~for~~ water levels in these areas exceed~~ing~~ 0,5 m ~~above the vehicle deck level~~ or the high water level alarm, whichever is the lesser. If not discharged by a bilge suction, scuppers are to be provided port and starboard having a diameter of not less than 50 mm. Valves are to be fitted.

3.10 Operating and Maintenance Manual

3.10.1 An Operating and Maintenance Manual for the bow doors and inner doors is to be provided on board.
The manual is to contain the following information:

(a) main particulars and design drawings,
- special safety precautions;
- details of vessel, class and statutory certificates;
- equipment and design loading for ramps;
- key plan of equipment for doors and ramps;
- manufacturers' recommended testing for equipment; and
- a description of the following equipment:
  - bow doors;
  - inner bow doors;
  - bow ramp/doors;
  - central power pack;
  - bridge panel;
  - ramps leading down from the main deck
  - engine control room panel.

(b) service conditions: ~~e.g. service area restrictions, acceptable clearances for supports,~~
- limiting heel and trim of the ship for loading/unloading;
- limiting heel and trim for door operations;
- operating instructions for doors and ramps; and
- emergency operating instructions for doors and ramps.

(c) maintenance: ~~and function testing,~~
- schedule and extent of maintenance;
- trouble shooting and acceptable clearances; and
- manufacturers' maintenance procedures.

(d) register of inspections, including inspection of locking, securing and supporting devices, ~~and~~ repairs and renewals.

This Manual is to be submitted for approval and is to contain a note recommending that recorded inspections of supporting and securing devices carried out by the ship's staff at monthly intervals, or following incidents that could result in damage, including heavy weather or contact in the region of the doors. Any damages recorded during such inspections are to be reported to LR.

■ *Section 4*
Side, stern doors and other shell openings

4.3 Scantlings

4.3.9 The scantlings of such primary members are to be based on direct strength calculations. Normally, formulae for simple beam theory may be applied to determine the bending stress. Members are to be considered to have simply supported end connections. The design load is the uniformly distributed external sea pressure, p_e, as defined in 4.8.1. For minimum scantlings, p_e, is to be taken as 25 kN/m^2 and the permissible stresses as follows:

$$\tau = \frac{80}{k_s} \text{ N/mm}^2$$

$$\sigma = \frac{120}{k_s} \text{ N/mm}^2$$

$$\sigma_e = \frac{150}{k_s} \text{ N/mm}^2$$

4.3.13 All load transmitting elements in the design load path from door, through securing arrangements and supporting devices, into the ship structure, including welded connections, are to be to the same strength standard as required for the securing and supporting devices. These elements include pins, supporting brackets and back-up brackets. Where cut-outs are made in the supporting structure, the strength and stiffness will be specially considered.

4.10 Operating and Maintenance Manual

4.10.1 An Operating and Maintenance Manual for the doors is to be provided on board.
The manual is to contain the following information:

(a) main particulars and design drawings,
- special safety precautions;
- details of vessel, class and statutory certificates;
- equipment and design loading for ramps;
- key plan of equipment for doors and ramps;
- manufacturers' recommended testing for equipment; and
- a description of the following equipment:
  - side doors;
  - stern doors;
  - central power pack;
  - bridge panel;
  - ramps leading down from the main deck;
  - engine control room panel.

(b) service conditions: ~~e.g. service area restrictions, acceptable clearances for supports,~~
- limiting heel and trim of the ship for loading/unloading;
- limiting heel and trim for door operations;
- operating instructions for doors and ramps; and
- emergency operating instructions for doors and ramps.

(c) maintenance: ~~and function testing,~~
- schedule and extent of maintenance;
- trouble shooting and acceptable clearances; and
- manufacturers' maintenance procedures.

(d) register of inspections, including inspection of locking, securing and supporting devices, repairs and renewals.

Volume 1, Part 5, Chapter 3
Local Design Loads

CORRIGENDA

■ *Section 3*
Loads on shell envelope

3.4 Hydrodynamic wave pressure, P_w

3.4.3 The distribution of hydrodynamic pressure up to the design waterline due to pitching motion, P_p, is to be taken as:

$P_p = 10\, H_{pm}$ kN/m^2

where

$$H_{pm} = 1{,}1 f_{Hs}\left(\frac{2x_{wl}}{L_{WL}} - 1\right)\sqrt{L_p}$$

but not less than $0{,}3 f_{Hs}\sqrt{L_{wL}}$

where

$L_P = L_{WL}$ but ≤ 150 m

x_{wl}, L_{WL} and f_{Hs} are defined in 1.3.

■ *Section 4*
Impact loads on external plating

4.2 Bottom impact pressure, IP_{bi}

(Part only shown)

4.2.1 The bottom impact pressure due to slamming, IP_{bi}, is to be derived using the method given below. This method will produce impact pressures over the whole of the underwater plating region:

H_{rm} = relative vertical motion based on V_{sp}, *see* Table 3.2.1

f_{sl} = probability level correction factor for relative vertical motion

= 1,0 ~~for ships with $C_b \leq 0{,}6$~~

= ~~1,2 for ships with $C_b > 0{,}6$~~

~~C_b = block coefficient as defied in Pt 3, Ch 1,5~~

V_{sp}, z, z_k and T_x are defined in 1.3

See Fig. 3.4.1.

4.3 Bow flare and above waterline wave impact pressures, IP_{bf}

(Part only shown)

4.3.1 The bow flare wave impact pressure, wave impact pressure on sponsons and other parts of the side shell plating above the design waterline, IP_{bf}, in kN/m^2, due to relative motion is to be taken as:

PR_{bf} = probability of a wave impact and is given by

$= e^{-u}$

$$u = \left(\frac{z_{wl}^2}{2m_0} + \frac{V_{thbf}^2}{2m_1}\right)$$

~~z_{wl}, m_1, m_0 are defined in 4.2 and~~

α_p = buttock angle measured in the longitudinal plane, in degrees, *see* Fig. 3.4.1

β_p = effective deadrise angle measured in the transverse plane, in degrees, *see* Fig. 3.4.1. For bow flare regions where the bow is non prismatic, i.e., changing rapidly, then β_p may be taken as the maximum of α_p or β_p. Note final β_p ~~the deadrise angle~~ is to be decreased by 10° with a minimum of 0° to allow for the effects of roll motion on the above waterline impact pressures for ships with $C_b \leq 0{,}6$

γ_p = waterline angle measured in the horizontal plane, in degrees, *see* Fig. 3.4.1

C_b = Block coefficient as defined in Pt 3, Ch 1,5

z_{wl}, m_1, m_0 are defined in 4.2 but are to be calculated using:

f_{sl} = probability level correction factor for relative vertical motion

= 1,0 for ships $C_b \leq 0{,}6$

= 1,2 for ships $C_b > 0{,}6$

NOTES

Where only two angles are known and are measured in the orthoganol planes, then the third angle may be obtained by the following expression.

$\alpha = \text{Tan}^{-1}(\text{Tan}\,\beta\ \text{Tan}\,\gamma)$

Volume 1, Part 6, Chapter 3
Scantling Determination

(Effective date 1 January 2005)

■ *Section 3*
NS1 scantling determination

3.14 Single and double bottom structures

Table 3.3.9 Superstructure plating

Location	Thickness, in mm
(1) Superstructure and deckhouse fronts, sides and backs	$t = 0{,}00126s\beta\sqrt{k_s P_{dh}}$
(2) Exposed decks on superstructures	$t = 0{,}00126s\beta\sqrt{k_s P_{wd}} + 1.5$
(3) Internal decks in superstructures and deckhouses	~~$t = 0{,}009s\beta\sqrt{k_s}$~~ $t = 0{,}0017s\beta\sqrt{k_s P_{in}}$
Symbols	
s, f, k_s as defined in 3.2.1 P_{dh} = deckhouse pressure, *see* Pt 5, Ch 3,5.5 P_{wd} = weather deck pressure, *see* Pt 5, Ch 3,3.5 P_{in} = internal deck pressure, *see* Pt 5, Ch 3,5.3 β = aspect ratio correction factor, *see* Ch 2,2.5.1	
NOTE Deckhouses and superstructures subjected to hull girder stress are to comply with the buckling requirements of Ch 2,4.	

Volume 1, Part 6, Chapters 3 & 6

CORRIGENDA

Table 3.3.12 Single bottom construction forward, minimum requirements *(Part only shown)*

Area	Item	Requirement
Transverse framing minimum requirements		
Centreline girder	Thickness, in mm	$t = 0{,}95\sqrt{L_R k_s}$ but not less than ~~6 mm at $0{,}075L_R$ and the basic taper thickness at $0{,}925L_R$~~ 6 mm forward of $0{,}925L_R$. Between $0{,}925L_R$ and $0{,}7L_R$, the thickness may taper to the midship thickness
	Modulus, in cm^3	the greater of: $Z = 8\,k_s\,S\,h_5\,l_e^2$ $Z = 8\,k_s\,S\,h_4\,l_e^2$
	Inertia, in cm^4	$I = \frac{2{,}5\,l_e^2\,Z}{k_s}$
Floors in tanks	Spacing Depth, in mm Thickness, in mm Face plate area, in cm^2	every frame $d_f = 83D + 150$ or 1400 whichever is the lesser $t = (5{,}5+0{,}23L_2)\sqrt{s_2/800}$ $A_f = 0{,}8S\,k_s\,B$
Girders in tanks	Spacing, in metres Depth, in mm Scantlings	$0{,}003s_f$ as for floors as midship region, *see* Table 3.2.1
Floors in dry spaces	Spacing Scantlings	every frame as midship region, *see* Table 3.2.1
Girders in dry spaces	Spacing, in mm Scantlings	$0{,}003s_f$ as midship region, *see* Table 3.2.1

Volume 1, Part 6, Chapter 6
Material and Welding Requirements

CORRIGENDUM

■ *Section 4*
Welded joints and connections

4.9 Intermittent welding (staggered and chain)

4.9.7 For ships with a shock enhanced notation, the extent of intermittent welding will be specially considered on the basis of the ~~sweat~~ threat levels.

Volume 2, Part 1, Chapter 1
General Requirements for Classification of Engineering Systems

(Effective date 1 January 2005)

■ *Section 8*
Quality assurance scheme for machinery

8.3 Arrangements for acceptance and certification of purchased material

(Part only shown)

8.3.2 The alternatives proposed in 8.3.1(b) and (c) are not acceptable to LR for the following items:

(a) Engine components for which testing is a Rule requirement, and
  (i) the cylinder bore is equal to or exceeds ~~250~~ 300 mm, or
  (ii) which are made by open forging techniques.
(b) Cast crankshafts where the journal diameter exceeds 85 mm.

Volume 2, Part 1, Chapter 2
Requirements for Design, Construction, Installation and Sea Trials of Engineering Systems

(Effective date 1 January 2005)

■ *Section 3*
Particulars to be submitted

3.3 Calculations and specifications

3.3.14 **Fin stabilisers.** Where fin stabiliser systems are fitted to a naval ship ~~to reduce the rolling motion of the ship to a stated limit~~, the following details are to be submitted:

(a) A design statement that details the stabiliser performance in terms of a specified roll angle that is not to be exceeded by more than a stated percentage of rolls in a specified wave environment (*see* Vol 1, Pt 5, Ch 2, 2.3) at a specified ship speed and heading. This statement is to be agreed between the Designer and Owner/Operator and recognise the requirements for ship-based operations, such as flight operations and replenishment at sea (RAS) systems, in terms of sea-keeping and platform heel/trim conditions, and the requirements of Section 4 regarding operating conditions as applicable. Details of any secondary function of the fin stabiliser to induce ship roll, for example to routinely test the fin stabiliser system (against its own induced roll), to facilitate weapon systems testing and to support NBC Protection pre-wetting systems, are also to be included in the design statement.
(b) Plans of all load bearing, torque transmitting components and hydraulic pressure retaining parts of the fin stabiliser system together with proposed rated torque, all relief valve settings and scantlings.
(c) Schematic plans of the hydraulic system(s), together with pipe material, relief valves and working pressures.
(d) Details of safety and control and electrical engineering arrangements.
(e) Material specifications for components identified in (b).
(f) Details of proposed testing and sea trials.
(g) Details of any limits of operation for stabilisation and induced forced roll, e.g., sea states, ship speed, roll amplitude and periodicity limitations.

3.3.15 **Machinery spaces and enclosures.** Evidence is to be submitted demonstrating the suitability of the fire extinguishing arrangements for a machinery space or enclosure as required by 15.12.2. The submission is to identify all standards applied in support of the proposed arrangements. The location of equipment, the degree of protection provided by the equipment itself, and the damage control and fire-fighting policy of the Navy or Naval Authority are to be taken into account in determination of the suitability of the fire extinguishing arrangements.

3.3.16 **Schedule of testing and trials.** Schedules of testing machinery at the manufacturers, pre-sea trial commissioning and sea trials are to be submitted to LR and agreed before commencement of testing and trials. The testing and trials schedules are to identify all modes of ship and machinery operation and the sea trials are to include typical port manoeuvres under all intended operating modes. Reference is also made to the following Rules:

- Vol 1, Pt 3, Ch 5, Section 8 -Windlass & capstan trials
- Vol 2, Pt 1, Ch.2, Section 15 - Steering systems
- Vol 2, Pt 1, Ch 2, Section 16 - Sea trials
- Vol 2, Pt 10, Ch 1, Section 20 - Electrical trials
- Vol 2, Pt 9, Ch 1, Section 6 - Control engineering trials

Testing and trials are to be witnessed by an LR Surveyor unless an alternative arrangement is agreed in writing prior to the trials by the Surveyor. Reports of testing and trials are to be submitted to an LR Surveyor after completion.

■ *Section 4* Operating conditions

4.5 Ambient operating conditions

4.5.1 Main and essential auxiliary machinery and equipment is to be capable of operating satisfactorily under the conditions shown in Table 2.4.1.

Existing paragraphs 4.5 to 4.19 are to be renumbered 4.6 to 4.20.

Table 2.4.1 Ambient operating conditions

Air		
Installations, Components	**Location, arrangement**	**Temperature range (ºC)**
Machinery and electrical installations, *see* Note 1	In enclosed spaces	0 to +45, *see* Note 2
	On machinery components, boilers, in spaces subject to higher and lower temperatures	According to specific conditions, *see* Note 3
	On the open deck	-25 to +45, *see* Note 2
Water		
Coolant		**Temperature (ºC)**
Sea water or charge air coolant inlet to charge air cooler		+32, *see* Note 2

NOTES
1. Electronic appliances are to be suitable for proper operation even with an air temperature of +55ºC.
2. For ships intended to be classed for restricted service, a deviation from the temperatures stated may be considered.
3. Details of local environmental conditions are stated in Annex B of IEC 60092: *Electrical installations in ships - Part 101: Definitions and general requirements.*

Existing Tables 2.4.1, 2.4.2 and 2.4.3 are to be renumbered 2.4.2, 2.4.3 and 2.4.4 respectively.

■ *Section 5* Machinery space arrangements

5.11 Machinery enclosures

5.11.1 Where machinery is installed within enclosures, the requirements of 5.11.2 to 5.11.10 and 5.12 ~~5.11.11~~ are to be complied with.

5.12 Fire detection, alarm and extinguishing arrangements

~~*5.11.11*~~ *5.12.1* Machinery spaces and enclosures are to be provided with fire detection, alarm and ~~extinction~~ extinguishing systems in accordance with the fire safety arrangements required by the Regulations in Vol 1, Pt 1, Ch 2,1.1.9. For unattended machinery spaces a fire detection system in accordance with Pt 9, Ch 1,3.5 is to be fitted.

5.12.2 The design of fire extinguishing arrangements in any machinery space or enclosure are to take the following into consideration:
(a) The flammable materials and potential sources of ignition within the space or enclosure;
(b) any need for machinery and equipment to remain operational during operation of the fire extinguishing arrangements;
(c) the need for machinery and equipment to continue to function normally following operation of the fire extinguishing arrangements; and
(d) any need for personnel to enter or remain within the space or enclosure during operation of the fire extinguishing arrangements.

In spaces where electrical equipment is located, consideration is to be given to providing separate enclosures where appropriate. *See also* 3.3.15.

CORRIGENDA

■ *Section 17* Failure Mode and Effects Analysis (FMEA)

17.1 General

17.1.2 The FMEA is to be carried out using the format presented in Table 2.17.1 or an equivalent format that addresses the same safety issues. Analysis in accordance with ~~IEC 812, *Analysis for System Reliability – Procedures for Failure Mode and Effects Analysis*~~ *IEC 60812, Analysis techniques for system reliability - Procedure for failure mode and effects analysis (FMEA)*, or IMO MSC Resolution 36(63) Annex 4 – *Procedures for Failure Mode and Effects Analysis*, would be acceptable.

Effective date 1 January 2005

■ *Section 18*
Fin stabilisers

18.1 Design and construction

18.1.2 Fin stabiliser actuating systems are to be consistent with the requirements of Vol 2, Pt 6, Ch 1, 5 ~~.~~ as applicable.

18.2 Performance and control

18.2.4 Where provision is made for an automatic forced roll facility, the roll amplitude and period are to be manually adjustable. Forced induction of rolling motion is not to result in an unsafe condition for the ship, equipment or the crew. The arrangements are also to satisfy the following:

(a) An automatic forced roll facility is to be selectable by a switch located on the navigating bridge which is located or protected so as to prevent inadvertent operation of this function.

(b) Controls are to be provided on the navigating bridge to manually adjust the amplitude and periodicity of the induced rolling.

18.2.4~~5~~ Failure of any part of the fin stabiliser unit or its control system is not to result in an unsafe condition which will have a detrimental effect on the ship's operating or sea-keeping capability.

18.2.~~5~~6 In the event of failure of the fin actuating system, a hand pump is to be provided, mounted in a readily accessible position, which is capable of centralising the fin in the absence of electrical power, and being operated by no more than two men when the ship is stopped.

18.3 Control, monitoring and alarms

18.3.1 Fin stabiliser actuating control arrangements are to be located in readily accessible positions that have means of communication provided to the machinery control station and the navigating bridge.

Volume 2, Part 2, Chapter 1
Diesel Engines

(Effective date 1 January 2005)

■ *Section 2*
Particulars to be submitted

2.1 Plans and information

2.1.1 At least three copies of the following plans are to be submitted:

- Crankshaft assembly plan (for each crank-throw).
- Crankshaft details plan (for each crank-throw).
- Thrust shaft or intermediate shaft (if integral with engine).
- ~~Thrust bearing assembly.~~
- Output shaft ~~C~~coupling bolts.
- ~~Counterweights, where attached to crankthrow.~~
- ~~Main engine holding down arrangement.~~
- Type and arrangement of crankcase explosion relief valves.
- Details of the securing and collision arrangements (*see also* Pt 1, Ch 2).
- Schematic oil fuel system, including controls and safety devices.
- High pressure parts for fuel oil injection system with specification of pressures, pipe dimensions and materials.
- Lubricating oil system.
- Starting air system.
- Cooling water system.
- Control engineering aspects in accordance with Part 9.
- Shielding of high pressure fuel pipes.
- Longitudinal and transverse cross-section.
- Cast bedplate, thrust bearing bedplate, crankcase and frames.
- Cylinder ~~cover~~ head assembly. ~~liner and jacket (or engine block).~~
- Cylinder liner.
- Piston assembly.
- Tie rod.
- Connecting rod, piston rod, and crosshead assemblies.
- Camshaft drive and camshaft general arrangement.
- Shielding and insulation of exhaust pipes.
- Details of turbochargers.
- Vibration dampers/detuners and moment compensators.
- Cross-sectional plans of the assembled turbo-charger with main dimensions.
- Fully dimensioned plans of the rotor.
- Material particulars with details of welding and surface treatments.
- Turbo-charger operating and test data.
- Manufacturer's Turbo-charger burst test assessment.
- For new engine types that have not been approved by LR, the proposed type test programme.
- The type test report on completion of type testing for a new engine type. For mass produced engines a separate report is to be submitted for each engine requiring approval, *see* 10.5.
- The specification for a mass produced engine including manufacturing processes and quality control procedures, *see* 10.1.4 and 10.2.3.
- Schematic layouts showing details and arrangements of oil mist detection/monitoring and alarm systems.

2.1.2 The following information and calculations are to be submitted.

- Crankshaft design data as outlined in Section 4.
- Combustion pressure-displacement relationship.
- Power/speed operational envelope.
- Calculations and information for short term high power operation where applicable.
- Arrangement and welding specifications with details of the procedures for fabricated bedplate, thrust bearing bedplate, crankcases, frames and entablatures. Details of materials, welding consumables, fit-up conditions, fabrication sequence and heat treatments are to be included.
- Operation and maintenance manuals.
- Material specifications covering the listed components together with details of any surface treatments, nondestructive testing and hydraulic tests.
- Arrangement of interior lighting, where provided.
- Engine Type test programme, where required including proposals for short term high power operation.
- Alternative proposals for hydraulic tests where design features are such that modifications to the test requirements are necessary.
- Thrust bearing assembly (if integral with engine and not integrated in the bedplate).
- Counterweights, where attached to crank-throw, including fastening.
- Main engine holding down arrangement.

2.1.5 A Failure Mode and Effects Analysis (FMEA) as required by Pt 1, Ch 2 is to be submitted. The FMEA is to include the following associated sub-systems:

- Starting and stopping.
- Oil fuel.
- Lubricating oil.
- Cooling water (fresh and sea).
- Air induction.
- Exhaust.
- Engine mounting.
- Control and monitoring.
- Electrical power supplies.
- Hydraulic oil (for valve lift)

It is not necessary to consider failure modes relating to the engine components.

2.1.6 Plans and details for dead ship condition starting arrangements are to be submitted for appraisal, *see* 7.1.

2.1.7 Where engines incorporate electronic control systems, a failure mode and effects analysis (FMEA) is to be submitted to demonstrate that failure of an electronic control system will not result in the loss of essential services for the operation of the engine and that operation of the engine will not be lost or degraded beyond an acceptable performance criteria of the engine. This is concerned with the functioning of the control system and not failure of the software itself.

Existing paragraph 2.1.6 is to be renumbered 2.1.8.

■ *Section 3*
Materials

Table 1.3.1 Material testing requirements
(Part only shown)

NOTES
1. For closed-die forged crankshafts the ultrasonic examination may be confined to the initial production and to subsequent occasional checks.
2. Magnetic particle or liquid penetrant testing of tie rods may be confined to the threaded portions and the adjacent material over a length equal to that of the thread.
3. Cylinder covers and liners manufactured from spheroidal or nodular graphite iron castings may not be suitable for ultrasonic NDE, depending upon the grain size and geometry. An alternative NDE procedure is to be agreed with LR.
4. Bore dimensions refer to engine cylinder bores.
5. All required material tests are to be witnessed in the presence of the Surveyor unless otherwise agreed by LR.
6. For mass produced engines, *see* Section 10.

■ *Section 5*
Construction and welded structures

5.1 Crankcases

5.1.1 Crankcases and their doors are to be of robust construction to withstand anticipated crankcase pressures that may arise during a crankcase explosion taking into account the installation of explosion relief valves required by Section 6 and the doors are to be securely fastened so that they will not be readily displaced by ~~an~~ a crankcase explosion.

■ *Section 6*
Safety arrangements on engines

6.1 Cylinder relief valves

~~*6.1.2* In the case of auxiliary engines, consideration will be given to the replacement of the relief valve by an efficient warning device of overpressure in the cylinder.~~

Existing paragraph 6.1.3 is to be renumbered 6.1.2

6.2 Crankcase relief valves

6.2.1 Crankcases are to be provided with lightweight spring-loaded valves or other quick-acting and self-closing devices, ~~of an approved type,~~ to relieve the crankcases of pressure in the event of an internal explosion and to prevent any inrush of air thereafter. The valves are to be designed and constructed to open quickly and be fully open at a pressure not greater than 0,2 bar. Crankcase relief valves are to be type tested in accordance with Section 12.

6.2.4 In engines having cylinders not exceeding 200 mm bore ~~and~~ or having a crankcase gross volume not exceeding 0,6 m^3, relief valves may be omitted.

6.2.12 In determining the volume of the crankcase for the purpose of calculating the combined free area of the crankcase relief valves, the volume of the stationary parts within the crankcase may be deducted from the total internal volume of the crankcase. The volume of the rotating and reciprocating components are to be included.

6.2.13 The valves are to be provided with a copy of the manufacturer's installation and maintenance manual that is pertinent to the size and type of valve being supplied for installation on a particular engine. The manual is to contain the following information:
(a) Description of valve with details of function and design limits.
(b) Copy of type test certification.
(c) Installation instructions.
(d) Maintenance in service instructions to include testing and renewal of any sealing arrangements.
(e) Actions required after a crankcase explosion.

6.2.14 A copy of the installation and maintenance manual required by 6.2.13 is to be provided on board ship.

6.2.15 Plans showing details and arrangements of the relief valves are to be submitted for approval. *See* 2.1.

6.2.16 The valves are to be provided with suitable markings that include the following information:
(a) Name and address of manufacturer.
(b) Designation and size.
(c) Month/Year of manufacture.
(d) Approved installation orientation.

6.3 Vent pipes

6.3.1 Ventilation of crankcase, and any arrangement which could produce a flow of external air within the crankcase, is in principle not permitted except for dual fuel engines where crankcase ventilation is to be provided. Where crankcase vent pipes are fitted, they are to be made as small as practicable to minimize the inrush of air after an explosion. Vents from crankcases of main engines are to be led to a safe position on deck or other approved position.

6.7 Oil mist detection/monitoring

6.7.1 Where crankcase oil mist detection/monitoring arrangements are fitted, they are to be of a type approved by LR, tested in accordance with Section 13 and comply with 6.7.2 to 6.7.15.

6.7.2 The oil mist detection/monitoring system and arrangements are to be installed in accordance with the engine designer's and oil mist manufacturer's instructions/recommendations. The following particulars are to be included in the instructions:

(a) Schematic layout of engine oil mist detection/monitoring and alarm system showing location of engine crankcase sample points and piping arrangements together with pipe dimensions to detector/monitor.
(b) Evidence of study to justify the selected location of sample points and sample extraction rate (if applicable) in consideration of the crankcase arrangements and geometry and the predicted crankcase atmosphere where oil mist can accumulate.
(c) The manufacturer's maintenance and test manual.
(d) Information relating to type or in-service testing of the engine with engine protection system test arrangements having approved types of oil mist monitoring equipment.

6.7.3 A copy of the oil mist detection/monitoring equipment maintenance and test manual required by 6.7.2 is to be provided on board ship.

6.7.4 Oil mist monitoring and alarm information is to be capable of being read from a safe location away from the engine.

6.7.5 Where there are multi engine installations, each engine is to be provided with oil mist detection/monitoring and a dedicated alarm.

6.7.6 Oil mist detection/monitoring and alarm systems are to be capable of being tested on the test bed and on board when the engine is at standstill and when the engine is running at normal operating conditions in accordance with test procedures that are acceptable to LR.

6.7.7 Alarms and shutdowns for the oil mist detection/monitoring system are to be in accordance with Pt 9 as applicable.

6.7.8 The oil mist detection/monitoring arrangements are to provide an alarm indication in the event of a foreseeable functional failure in the equipment and installation arrangements.

6.7.9 The oil mist detection/monitoring system is to provide an indication that any lenses fitted in the equipment and used in determination of the oil mist level have been partially obscured to a degree that will affect the reliability of the information and alarm indication.

6.7.10 Where oil mist detection/monitoring equipment includes the use of programmable electronic systems, the arrangements are to be in accordance with Pt 9 as applicable.

6.7.11 Schematic layouts showing details and arrangements of oil mist detection/monitoring and alarm systems are to be submitted. *See* Pt 2, Ch 1,2.1.

6.7.12 The equipment together with detectors/monitors is to be tested when installed on the test bed and on board ship to demonstrate that the detection/monitoring and alarm system functionally operates. The testing arrangements are to be to the satisfaction of the Surveyor.

6.7.13 Where sequential oil mist detection/monitoring arrangements are provided the sampling frequency and time is to be as short as reasonably practicable.

6.7.14 Where alternative methods are provided for the prevention of the build-up of oil mist that may lead to a potentially explosive condition within the crankcase, detailed information is to be submitted for consideration. The information is to include:

(a) Engine particulars - type, power, speed, stroke, bore and crankcase volume.
(b) Details of arrangements designed to prevent the build up of potentially explosive conditions within the crankcase, e.g., bearing temperature monitoring, oil splash temperature monitoring, crankcase pressure monitoring, and recirculation arrangements.
(c) Evidence to demonstrate that the arrangements are effective in preventing the build up of potentially explosive conditions together with details of in-service experience.
(d) Operating instructions and the maintenance and test instructions.

6.7.15 Where it is proposed to use the introduction of inert gas into the crankcase to minimise a potential crankcase explosion, details of the arrangements are to be submitted for consideration.

■ *Section 7* Starting arrangements

~~7.1 Initial starting arrangements~~

~~*7.1.1* Equipment for starting the main and auxiliary engines is to be provided so that the necessary initial charge of starting air or initial electric power can be developed on board ship without external aid. If for this purpose an emergency air compressor or electric generator is required, these units are to be power driven by hand starting oil engine, except in the case of small installations where a hand operated compressor of approved capacity may be accepted. Alternatively, other devices of approved type may be accepted as a means of providing the initial start.~~

7.1 Dead ship condition starting arrangements

7.1.1 Means are to be provided to ensure that machinery can be brought into operation from the dead ship condition without external aid.

7.1.2 Dead ship condition for the purpose of 7.1.1 is to be understood to mean a condition under which the main propulsion plant, boilers and auxiliaries are not in operation. In restoring propulsion, no stored energy for starting and operating the propulsion plant is assumed to be available. Additionally, neither the main source of electrical power nor other essential auxiliaries is assumed to be available for starting and operating the propulsion plant.

7.1.3 Where the emergency source of power is an emergency generator which fully complies with the requirements of Pt 10, Ch 1 of the Rules, this generator may be used for restoring operation of the main propulsion plant, boilers and auxiliaries where any power supplies necessary for engine operation are also protected to a similar level as the starting arrangements.

7.1.4 Where there is no emergency generator installed or an emergency generator does not comply with Pt 10, Ch 1 of the Rules, the arrangements for bringing main and auxiliary machinery into operation are to be such that the initial charge of starting air or initial electrical power and any power supplies for engine operation can be developed on board ship without external aid. If for this purpose an emergency air compressor or an electric generator is required, these units are to be powered by a hand-starting oil engine or a hand-operated compressor. The arrangements for bringing main and auxiliary machinery into operation are to have capacity such that the starting energy and any power supplies for engine operation are available within 30 minutes of a dead ship condition.

■ *Section 9*
Control and monitoring

9.7 Diesel engines for propulsion purposes

Notes 1 and 2 of Table 1.9.2 are to be deleted.

■ *Section 10*
Alarms and safeguards for emergency diesel engines

10.1 General

10.1.1 These requirements apply to emergency diesel engines required to be immediately available in an emergency and capable of being controlled remotely or automatically.

10.1.2 Alarms and safeguards are indicated in Table 1.10.1. *See also* 9.1.2 and 9.6.3.

Table 1.10.1 Alarms and safeguards for diesel engines

Item	Alarm	Alarm	Note
Emergency Diesel Engine	≥ 220 kW	< 220 kW	-
Fuel oil leakage from pressure pipes	Leakage	Leakage	*See* 9.6.3
Lubricating oil temperature	High	-	-
Lubricating oil pressure	Low	Low	-
Oil mist concentration in crankcase	High	-	*See* Note 1
Coolant pressure or flow	Low	-	-
Coolant Temperature (can be air)	High	High	-
Overspeed	High	-	Automatic shutdown

NOTE
1. For engines having a power of more than 2250 kW or a cylinder bore of more than 300 mm.

10.1.3 The safety and alarm systems are to be designed to 'fail safe'. The characteristics of the 'fail safe' operation are to be evaluated on the basis not only of the system and its associated machinery, but also the complete installation, as well as the ship.

10.1.4 Regardless of the engine output, if shutdowns additional to those specified in Table 1.10.1 are provided except for the overspeed shutdown, they are to be automatically overridden when the engine is in automatic or remote control mode during navigation.

10.1.5 Grouped alarms of at least those items listed in Table 1.10.1 are to be arranged on the bridge.

10.1.6 In addition to the fuel oil control from outside the space, a readily accessible local means of engine shutdown is to be provided.

10.1.7 Local indications of at least those items listed in Table 1.9.3 are to be provided within the same space as the diesel engines and are to remain operational in the event of failure of the alarm and safety systems.

Section 11
Mass produced engines

11.1 Definition

11.1.1 Mass produced engines, for main and auxiliary purposes, are defined as those which are produced under the following criteria:

(a) In quantity under strict quality control of material and parts, according to a quality assurance scheme acceptable to LR.
(b) By the use of jigs and automatic machine tools designed to machine parts to specified tolerances for interchangeability, and which are verified on a regular inspection basis.
(c) By assembly with parts taken from stock and requiring little or no fitting.
(d) With bench tests carried out on individual assembled engines according to a specified programme.
(e) With appraisal by final examination of engines selected at random after workshop testing.

11.1.2 Castings, forgings and other parts for use in mass produced engines are also to be produced by methods similar to those given in 11.1.1 (a), (b) and (c), with appropriate inspection.

11.1.3 Pressure testing of components is to comply with Pt 1, Ch 2,6.3.

11.1.4 The specification of a mass produced engine is to define the limits of manufacture of all component parts. The total production output is to be certified by the manufacturer and verified as may be required, by LR in accordance with the agreed manufacturer's quality assurance scheme, *see* 11.1.1 (a).

11.2 Procedure for approval of mass produced engines

11.2.1 The procedure outlined in 11.2.2 to 11.2.5 applies to the inspection and certification of mass produced oil engines having a bore not exceeding 300 mm.

11.2.2 For the approval of a mass produced engine type, the manufacturer is to submit, in addition to the plans and particulars required by Pt 2, Ch 1 a list of sub-contractors for main parts.

11.2.3 The manufacturer is to supply full information regarding the manufacturing processes and quality control procedures applied in the workshops. The information is to address the following:

(a) Organisation of quality control systems.
(b) Recording of quality control operations.
(c) Qualification and independence of personnel in charge of quality control.

11.2.4 A running type test of at least 100 hours duration is to be carried out on an engine chosen from the production line. The type testing is to comply with 11.5.

11.2.5 LR reserves the right to limit the duration of validity of approval of a mass produced engine. LR is to be informed, without delay, of any change in the design of the engine, in the manufacturing or control processes or in the selection of materials.

11.3 Continuous review of production

11.3.1 LR Surveyors are to be provided with free access to the manufacturer's workshops and to the quality control files.

11.3.2 The control of production, which is subject to survey, is to include the following:

(a) Inspection and testing records are to be maintained to the satisfaction of the Surveyor.
(b) The system for identification of parts is to be in accordance with recognised practice, acceptable to LR.
(c) The manufacturer is to provide full information about the quality control of the parts supplied by subcontractors for which certification may be required. LR reserves the right to apply direct and individual inspection procedures for parts supplied by subcontractors when deemed necessary.
(d) At the request of an attending LR surveyor, a workshop test may be required for an individual engine.

11.4 Compliance and inspection certificate

11.4.1 Each engine which is to be installed on a naval ship classed by LR is to be supplied with a statement certifying that the engine is identical to the one which underwent the tests specified in 11.2.4, and state the test and inspection results. The statement is to be made on a form agreed with LR. Each statement is to include the identification number which appears on the engine. A copy of this statement is to be submitted to LR.

11.5 Type test conditions

11.5.1 The requirements in this section are applicable to the type testing of mass produced internal combustion engines where the manufacturer has requested approval. Omission or simplification of the type test requirements will be considered by LR for engines of an established type on application by the manufacturer.

11.5.2 The engine to be tested is to be selected from the production line and agreed by LR.

11.5.3 The duration and programme of type tests is to include the following:
(a) 80 h at rated output
(b) 8 h at 110% overload
(c) 10 h at partial loads (25%, 50%, 75% and 90% of rated output)
(d) 2 h at intermittent loads
(e) Starting tests
(f) Reverse running of direct reversing engines
(g) Testing of speed governor
(h) Testing of over-speed device
(j) Testing of lubricating oil system failure alarm device
(k) Testing of the engine with turbocharger out of action when applicable.
(l) Testing of minimum speed for main propulsion engines and the idling speed for auxiliary engines.

11.5.4 The type tests in 11.5.3 at the required outputs are to be combined together in working cycles for the whole duration within the limits indicated. *See also* 11.5.10 and 11.5.11.

11.5.5 The overload testing required by 11.5.3 may alternately be carried out with the following:
(a) 110% of rated power output at 103% revolutions per minute
(b) 110 % of rated power output at 100% revolutions per minute.

11.5.6 For prototype engines, the duration and programme of tests are to be specially agreed between the manufacturer and LR.

11.5.7 During type testing the following particulars are to be recorded:
(a) Ambient air temperature
(b) Ambient air pressure
(c) Atmospheric humidity
(d) External cooling water temperature
(e) Fuel and lubrication oil characteristics.

11.5.8 In addition to the particulars stated in 11.5.7, the following are also to be measured or recorded:
(a) Engine revolutions per minute
(b) Brake power
(c) Torque
(d) Maximum combustion pressure
(e) Indicator pressure diagrams where practicable
(f) Exhaust smoke (with an approved smoke meter)
(g) Lubricating oil pressure and temperature
(h) Exhaust gas temperature in exhaust manifold, and, where facilities are available, from each cylinder.
(j) For turbocharged engines:
- Turbocharger revolutions per minute.
- Air temperature and pressures before and after turbo-blower and charge cooler.
- Exhaust gas temperature and pressures before and after the turbine.
- The cooling water inlet temperature to the charge air cooler.

11.5.9 After the type test, the main parts and especially those subject to wear are to be dismantled for examination by LR Surveyors.

11.5.10 For engines that are required to be approved for different purposes (multi-purpose engines), and that have different performances for each purpose, the programme and duration of test is to be modified to cover the whole range of the engine performance taking into account the most severe conditions.

11.5.11 The rated output for which the engine is to be tested is the output corresponding to that declared by the manufacturer and agreed by LR, i.e. actual maximum power which the engine is capable of delivering continuously between the normal maintenance intervals stated by the manufacturer at the rated speed and under the stated ambient conditions.

■ *Section 12*
Mass produced turbo-chargers

12.1 Application

12.1.1 The following procedure applies to the inspection and testing of exhaust driven turbo chargers which are manufactured on the basis of mass production methods similar to 11.1 as applicable and for which the maker has requested approval.

12.2 Procedure for approval of mass produced turbo-chargers

12.2.1 The procedure outlined in 12.2.2 to 12.2.5 applies to the inspection and certification of mass produced turbo-chargers when a simplified method of inspection has been requested by the manufacturers.

12.2.2 For the approval of a mass produced turbo-charger, the manufacturer is to submit, in addition to the plans and particulars required by Pt 2, Ch 1 as applicable, a list of main current suppliers and subcontractors for rotating parts and an operation and maintenance manual.

12.2.3 The manufacturer will supply full information regarding the material and quality control system used in the organization as well as the inspection methods, the way of recording and proposed frequency, and the method of material testing of important parts.

12.2.4 A Type test (*see* Pt 1, Ch 2,7.2) is to be carried out on a standard unit taken from the assembly line and is to be witnessed by the Surveyor. The performance data which may have to be verified are to be made available at the time of the type test. For manufacturers who have facilities for testing the turbo-charger unit on an engine for which the turbo-charger is to be type approved, substitution of the hot running test by a test run of one hour's duration at overload (110% of the rated output) may be considered.

12.2.5 LR reserves the right to limit the duration of validity of approval of a mass produced turbo-charger. LR is to be informed, without delay, of any change in the design of the turbo-charger, in the manufacturing or control processes or in the selection of materials.

12.3 Continuous inspection of individual units

12.3.1 LR Surveyors are to be provided with free access to the manufacturer's workshop to inspect at random the quality control measures and to witness the under mentioned tests as deemed necessary, as well as to have free access to all control records and subcontractors' certificates.

12.3.2 Each individual unit is to be tested in accordance with 12.3.4 to 12.3.7 by the maker who is to issue a final certificate.

12.3.3 Rotating parts of the turbo-charger blower are to be marked for easy identification with the appropriate certificate.

12.3.4 Material tests of the rotating parts are to be carried out by the maker or his subcontractor in accordance with the requirements of the Rules for Materials (Part 2) as applicable. The relevant certificate is to be produced and filed to the satisfaction of the Surveyor.

12.3.5 Pressure test is to be carried out in accordance with Table 2.6.1. In general, the pressure tests are to be carried out as indicated. Special consideration will be given where design or testing features may require modification of the test requirements.

12.3.6 Dynamic balancing and overspeed test is to be carried out, *see* Pt 1, Ch 2,7.3 and 7.4, in accordance with the approved procedure for quality control. If each forged wheel is individually controlled by an approved non-destructive examination method no overspeed test may be required except for wheels of type test unit.

12.3.7 A mechanical running, *see* Pt 1, Ch 2,7.5 is to be carried out. The duration of the running test may be reduced to 10 minutes provided that the manufacturer is able to verify the distribution of defects established during the running tests on the basis of a sufficient number of tested turbo-charges. For manufacturers who have facilities in their Works for testing the turbo-chargers on an engine for which the turbo-chargers are intended, the bench test may be replaced by a test run of 20 minutes at overload (110% of the rated output) on this engine.

12.4 Compliance and certificate

12.4.1 For every turbo-charger unit liable to be installed on an engine intended for a naval ship classed by LR, the manufacturer is to supply a statement certifying that the turbo-charger is identical with one that underwent the tests specified in 12.2.4 and that prescribed tests were carried out. Results of these tests are to be also stated. This statement is to be made on a form agreed with LR and a copy is to be sent to LR. Each statement must have a number which is to appear on the turbo-charger.

■ *Section 13*
Type testing procedure for crankcase explosion relief valves

13.1 Scope

13.1.1 This test procedure has been developed to identify standard conditions by which crankcase explosion relief valves intended to be fitted to diesel engines can be tested to demonstrate that they satisfy LR requirements for type testing to a defined standard.

13.1.2 This test procedure is also applicable to explosion relief valves intended for gear cases.

13.1.3 Standard repeatable test conditions have been established using methane gas and air mixture.

13.1.4 The test procedure is only applicable to explosion relief valves fitted with flame arresters.

13.2 Recognised Standards

13.2.1 The following standards have been used to develop this test procedure:

- EN 12874:2001: Flame arresters - Performance requirements, test methods and limits for use.
- EN ISO/IEC 17025:2000: General requirements for the competence of testing and calibration laboratories.
- EN 1127-1:1998: Explosive atmospheres - Explosion prevention and protection. Part 1. Basic concepts and methodology.
- EN 1070:1998: Safety of Machinery - Terminology.
- VDI 3673: Part 1: Pressure Venting of Dust Explosions.
- IMO MSC/Circular 677 - Revised Standards for the Design, Testing and Locating of Devices to Prevent the Passage of Flame into Cargo Tanks in Tankers.

13.3 Purpose

13.3.1 The purpose of type testing crankcase explosion relief valves is fourfold:

(a) To verify the effectiveness of the flame arrester.
(b) To verify that the valve closes after an explosion.
(c) To verify that the valve is gas/air tight after an explosion.
(d) To establish the level of over pressure protection provided by the valve.

13.4 Test facilities

13.4.1 The test facilities for carrying out type testing of crankcase explosion relief valves are to meet the following criteria:

(a) The test facilities where testing is carried out are to be accredited to a National or International Standard for the testing of explosion protection devices.
(b) The test facilities are to be acceptable to LR.
(c) The test facilities are to be equipped so that they can control and record explosion testing in accordance with this procedure.
(d) The test facilities are to have equipment for controlling and measuring a methane gas in air concentration within a test vessel to an accuracy of ± 0.1%.

(e) The test facilities are to be capable of effective point located ignition of methane gas in air mixture.

(f) The pressure measuring equipment is to be capable of measuring the pressure in the test vessel in at least two positions. One at the valve and the other at the test vessel centre. The measuring arrangements are to be capable of measuring and recording the pressure changes throughout an explosion test. The result of each test is to be documented by video recording and if necessary by recording with a heat sensitive camera.

(g) The test vessel for explosion testing is to have documented dimensions that are to be such that its height or length between dished ends is approximately 2 times its diameter but not more than 2.5 times. The internal volume of the test vessel is to be determined from the vessel dimensions that include any standpipe arrangements.

(h) The test vessel for explosion testing is to be provided with a flange for mounting the explosion relief valve in an orientation consistent with how it will be installed in service, i.e., in the vertical plane or the horizontal plane. The flange arrangement is to be made approximately one third of the height or length of the test vessel.

(j) A circular flat plate having the following dimensions is to be provided for fitting between the pressure vessel flange and valve to be tested:
(i) Outside diameter = 2 x D where D is the outer diameter of the valve top cover. The circular plate is to provide simulation of the crankcase surface.
(ii) Internal bore having the same internal diameter of the valve to be tested.

(k) The test vessel for explosion testing is to have connections for measuring the methane in air mixture in at least two positions, i.e., top and bottom.

(l) The test vessel for explosion testing is to be provided with a means of fitting an ignition source at a position approximately one third the height or length of the vessel.

(m) The test vessel volume is to be as far as practicable, related to the size of relief valve to be tested. In general, the volume is to correspond to the requirement in 6.3.1 for the free area of explosion relief valve to be not less than 115cm2/m^3 of crankcase gross volume, i.e., the testing of a valve having 1150cm^2 of free area, would require a test vessel with a volume of 10m^3. In any case the volume of the test vessel is not to vary by more than +15% to -10% from the 115cm^2/m^3 volume ratio.

13.5 Explosion test process

13.5.1 All explosion tests to verify the functionality of crankcase explosion relief valves are to be carried out using an air and methane mixture with a methane concentration of 9.5% ±0.5%. The pressure in the test vessel is to be not less than atmospheric and not exceed 0.2 bar.

13.5.2 The concentration of methane in the test vessel is to be measured in the top and bottom of the vessel and is not to differ by more than 0.5%.

13.5.3 The ignition of the methane and air mixture is to be made at a position approximately one third of the height or length of the test vessel opposite to where the valve is mounted.

13.5.4 The ignition is to be made using a 100 joule explosive charge.

13.6 Valves to be tested

13.6.1 The valves used for type testing are to be manufactured and tested in accordance with procedures acceptable to LR and selected from the manufacturer's usual production line for such valves by the LR Surveyor witnessing the tests.

13.6.2 For approval of a specific valve size, three valves of that specific size are to be tested. The valves are to have been tested at the manufacturer's works to demonstrate that the opening pressure is 0.05bar ± 20% and that the valve is air tight at a pressure below the opening pressure for at least 30 seconds.

13.6.3 The selection of valves for type testing is to recognise the orientation that they are intended to be installed on the engine or gear case. Where it is intended that valves be installed in the vertical or near vertical or the horizontal or near horizontal position, then three valves of each size are to be tested for each intended orientation.

13.7 Method

13.7.1 The following requirements are to be satisfied at explosion testing:

(a) The explosion testing is to be witnessed by a LR Surveyor where type testing approval is required by LR.

(b) Valves are to be tested in the vertical or horizontal position consistent with the orientation in which they are intended to be installed on an engine or gear case, usually in the vertical position, *see* 13.6.3.

(c) Where valves are to be installed on an engine or gear case with shielding arrangements to deflect the emission of explosion combustion products, the valves are to be tested with the shielding arrangements fitted.

(d) Type testing is to be carried out for each range of valves that a manufacturer requires LR approval.

(e) Successive explosion testing to establish a valve's functionality is to be carried out as quickly as possible during stable weather conditions.

(f) The pressure rise and decay during all explosion testing is to be recorded.

(g) The external condition of the valves is to be monitored during each test. The test facility is to produce a report on the explosion test findings.

13.7.2 The explosion testing is to be in three stages for each valve that is required to be approved as being type tested.

13.7.3 Stage 1:
Two explosion tests are to be carried out with the flange opening fitted with the circular plate covered by a 0.05mm thick polythene film. These tests establish a reference pressure level for determination of the effects of a relief valve in terms of pressure rise in the test vessel, *see* 13.8.1 (f).

13.7.4 Stage 2:

(a) Two explosion tests are to be carried out on three different valves of the same size. Each valve is to be mounted in the orientation that it requires approval for installation i.e., in the vertical or horizontal position with the circular plate described in 13.4.1(j) located between the valve and pressure vessel mounting flange.

(b) The first of the two tests on each valve is to be carried out with a 0.05 mm thick polythene bag having a minimum diameter of three times the diameter of the circular plate and volume not less than 30% of the test vessel enclosing the valve and circular plate. Before carrying out the explosion test the polythene bag is to be empty of air. The plastic bag is required to provide a readily visible means of assessing whether there is flame transmission through the relief valve following an explosion consistent with the requirements of the standards identified in 13.2.

(c) Provided that the first explosion test successfully demonstrated that there was no indication of combustion outside the flame arrester and there are no signs of damage to the flame arrester or valve, a second explosion test without the polythene bag arrangement is to be carried out. During the second explosion test, the valve is to be visually monitored for any indication of combustion outside the flame arrester. The second test is required to demonstrate that the valve can function in the event of a secondary crankcase explosion.

(d) After each explosion, the test vessel is to be maintained in the closed condition for at least 10 seconds to enable the tightness of the valve to be ascertained. The tightness of the valve can be verified during the test from the pressure/time records or by a separate test after completing the second explosion test.

13.7.5 Stage 3:

Two further explosion tests are to be carried out as described in Stage 1. These further tests are required to provide an average base line value for assessment of pressure rise recognising that the test vessel ambient conditions may have changed during the testing of the explosion relief valves in Stage 2.

13.8 Assessment

13.8.1 Assessment of the valves after explosion testing is to address the following points:

(a) The valves to be tested are to have evidence of appraisal/approval by LR, *see also* 13.6.1.

(b) The designation, dimensions and characteristics of the valves to be tested are to be recorded. This is to include the valve free area and of the flame arrester and valve lift at 0.2 bar.

(c) The test vessel volume is to be determined and recorded.

(d) For acceptance of the functioning of the flame arrester there is not to be any indication of flame or combustion outside the valve during an explosion test.

(e) The pressure rise and decay during an explosion is to be recorded with indication of the pressure variation showing the maximum overpressure and steady under pressure in the test vessel during testing. The pressure variation is to be recorded at two points in the pressure vessel.

(f) The effect of an explosion relief valve in terms of pressure rise following an explosion is ascertained from maximum pressures recorded at the centre of the test vessel during the three stages. The pressure rise within the test vessel due to the installation of a relief valve is the difference between average pressure of the four explosions from Stages 1 and 3 and the average of the first tests on the three valves in Stage 2.

(g) The valve tightness is to be ascertained by verifying from records that an under pressure of at least 0.3 bar is held by the test vessel for at least 10 seconds following an explosion.

(h) After each explosion test in Stage 2, the external condition of the flame arrester is to be examined for signs of damage and/or deformation.

(j) After completing the explosion tests, the valves are to be dismantled and the condition of all components ascertained and documented. In particular any indication of valve sticking or uneven opening is to be noted. Photographic records of the valve condition are to be taken and included in the report.

13.9 Design series qualification

13.9.1 The qualification of quenching devices to prevent the passage of flame can be evaluated for other similar devices of identical where one device has been tested and found satisfactory.

13.9.2 The quenching ability of a flame screen depends on the total mass of quenching lamellas/mesh. Provided the materials, thickness of materials, depth of lamellas/thickness of mesh layer and the quenching gaps are the same, then the same quenching ability can be qualified for different size of flame screen. This is subject to (a) and (b) being satisfied.

(a) $\frac{n_1}{n_2} = \sqrt{\frac{S_1}{S_2}}$ (b) $\frac{A_1}{A_2} = \frac{S_1}{S_2}$

where:

n_1 = number of lamellas of size 1 quenching device for a valve with a relief area equal to S_1

n_2 = number of lamella of size 2 quenching device for a valve with a relief area equal to S_2

A_1 = free area of quenching device for a valve with a relief area equal to S_1

A_2 = free area of quenching device for a valve with a relief area equal to S_2

13.10 The report

13.10.1 The test facility is to deliver a full report that includes the following information and documents:

(a) Test specification.

(b) Details of test pressure vessel and valves tested.

(c) The orientation in which the valve was tested, (vertical or horizontal position).

(d) Methane in air concentration for each test.

(e) Ignition source.

(f) Pressure curves for each test.

(g) Video recordings of each valve test.

13.11 Approval

13.11.1 Approval of an explosion relief valve is the prerogative of LR based on the appraisal of plans and particulars and the test facilities report of the results of type testing.

■ *Section 14*
Type Testing Procedure for crankcase oil mist detection/monitoring and alarm arrangements

14.1 Scope

14.1.1 This test procedure has been developed to identify standard conditions by which crankcase oil mist detection/monitoring and alarm equipment and systems intended to be fitted to diesel engines can be tested to demonstrate that they satisfy LR requirements for type testing to a defined standard.

14.1.2 This test procedure is also applicable to oil mist detection/monitoring and alarm arrangements intended for gear cases.

14.2 Recognised Standards

14.2.1 This test procedure is based on IACS Unified Requirement E10 Type Test Specification.

14.3 Purpose

14.3.1 The purpose of type testing crankcase oil mist detection/monitoring and alarm arrangements is seven fold:

(a) To verify the functionality of the system.
(b) To verify the effectiveness of the oil mist detectors.
(c) To verify the accuracy of oil mist detectors.
(d) To verify the alarm set points.
(e) To verify time delays between mist extraction from crankcase and alarm activation.
(f) To verify the operation of alarms to indicate functional failure in the equipment and associated arrangements.
(g) To verify that there is an indication of lens obscuration to a level that will affect the reliability of information and alarms.

14.4 Test facilities

14.4.1 The test house carrying out type testing of crankcase oil mist detection/monitoring and alarm equipment and arrangements are to satisfy the following criteria:

(a) The test facilities are to have the full range of facilities for carrying the type and functionality tests required by this procedure and be acceptable to LR.
(b) The test facilities that verify that the equipment ascertains the levels of oil mist concentration are to be equipped so that they can control, measure and record oil mist concentration levels in terms of mg/l to an accuracy of ± 10% accordance with this procedure.
(c) The type tests are to be witnessed by a LR Surveyor unless otherwise agreed.
(d) The oil mist concentrations are to be ascertained by the gravimetric deterministic method or equivalent. The gravimetric deterministic method is a laboratory process where the difference in weight of a milipore (typically 0.8 m) filter is ascertained from weighing the filter before and after drawing $1m^3$ of oil mist through the filter.
(e) The results of a gravimetric analysis are considered invalid and are to be rejected if the resultant calibration curve has an increasing gradient with respect to the oil mist detection/monitoring reading. This situation occurs when insufficient time has been allowed for the oil mist to become homogeneous. Single results that are more than 10% below the calibration curve are to be rejected. This situation occurs when the integrity of the filter unit has been compromised and not all of the oil is collected on the filter paper.
(f) The filters require to be weighed to a precision of 0.1mg and the volume of air/oil mist sampled to 10ml.

14.5 Equipment testing

14.5.1 The range of tests is to include the following for alarm/monitoring panel:

(a) Functional tests described in 14.6.
(b) Electrical power supply failure test.
(c) Power supply variation test.
(d) Dry heat test.
(e) Damp heat test.
(f) Vibration test.
(g) EMC test.
(h) Insulation resistance test.
(j) High voltage test.
(k) Static and dynamic inclinations, if moving parts are contained.

14.5.2 The range of tests is to include the following for the detectors:

(a) Functional tests described in 14.6.
(b) Electrical power supply failure test.
(c) Power supply variation test.
(d) Dry heat test.
(e) Damp heat test.
(f) Vibration test.
(g) Insulation resistance test.
(h) High voltage test.
(j) Static and dynamic inclinations, if moving parts are contained.

14.6 Functional test process

14.6.1 All tests to verify the functionality of crankcase oil mist detection/monitoring devices are to be carried out in accordance with 14.6.2 to 14.6.6 with an oil mist concentration in air, known in terms of mg/l to an accuracy of ±10%.

14.6.2 The concentration of oil mist in the test vessel is to be measured in the top and bottom of the vessel and is not to differ by more than 10%.

14.6.3 The oil mist monitoring arrangements are to be capable of detecting oil mist in air concentrations of between 0 and 10% of the lower explosive limit (LEL). Note: The LEL corresponds to an oil mist concentration of approximately 50mg/l (13% oil-air mixture).

14.6.4 The operation of the alarm indicators for oil mist concentration in air are to be verified and are to provide an alarm at a maximum setting corresponding to 5% of the LEL corresponding to approximately 2.5mg/l.

14.6.5 Where alarm set points can be altered, the means of adjustment and indication are to be verified against the equipment manufacturer's instructions.

14.6.6 Where oil mist is drawn into a detector/monitor via piping arrangements, the time delay between the sample leaving the crankcase and operation of the alarm is to be determined for the longest and shortest lengths of pipes recommended by the manufacturer. The pipe arrangements are to be in accordance with the manufacturer's instructions/recommendations.

14.7 Detectors/monitors and equipment to be tested

14.7.1 The detectors/monitors and equipment used in type testing are to be manufactured and tested in accordance with procedures acceptable to LR and selected from the manufacturer's usual production line for such equipment by the LR surveyor witnessing the tests.

14.7.2 Two sets of detectors/monitors requiring approval are to be tested. One set is to be tested in the clean condition and the other in a condition that represents the maximum degree of lens obscuration that is stated as being acceptable by the manufacturer.

14.8 Method

14.8.1 The following requirements are to be satisfied at type testing:

(a) The testing is to be witnessed by a LR surveyor where type testing approval is required by LR.
(b) Oil mist detection/monitoring devices are to be tested in the orientation in which they are intended to be installed on an engine or gear case.
(c) Type testing is to be carried out for each range of oil mist detection/monitoring devices that a manufacturer requires LR approval.
(d) The test house is to produce a test report.

14.9 Assessment

14.9.1 Assessment of oil mist detection/monitoring devices after testing is to address the following points:

(a) The devices to be tested are to have evidence of appraisal/approval by LR, *see also* 14.7.1.
(b) The details of the detection/monitoring devices to be tested are to be recorded. This is to include manufacturer, type designation, oil mist concentration assessment capability and alarm settings.
(c) After completing the tests, the detection/monitoring devices are to be examined and the condition of all components ascertained and documented. Photographic records of the monitoring devices condition are to be taken and included in the report.

14.10 Design series qualification

14.10.1 The approval of one detection/monitoring device may be used to qualify other devices having identical construction details. Proposals are to be submitted for consideration.

14.11 The Report

14.11.1 The test house is to provide a full report that includes the following information and documents:

(a) Test specification.
(b) Details of devices tested.
(c) Results of tests.

14.12 Acceptance

14.12.1 Acceptance of crankcase oil mist detection/monitoring devices is the prerogative of LR based on the appraisal plans and particulars and the test facilities report of the results of type testing.

14.12.2 The following information is to be submitted to LR for acceptance of oil mist detection/monitoring and alarm arrangements:

(a) Description of oil mist detection/monitoring equipment and system including alarms.
(b) Copy of the test house report identified in Section 14.11.
(c) Schematic layout of engine oil mist detection/monitoring arrangements showing location of detectors/sensors and piping arrangements and dimensions.
(d) Maintenance and test manual which is to include the following information:
    - Intended use of equipment and its operation.
    - Functionality tests.
    - Maintenance routines and spare parts recommendations.
    - Limit setting and instructions for safe limit levels.
    - Where necessary, details of configurations in which the equipment is and is not to be used.

Section 15
Electronically controlled engines

15.1 Scope

15.1.1 The requirements of this section are applicable to engines for propulsion, auxiliary and emergency power purposes with software based electronic control of fuel, air and exhaust systems.

15.1.2 These engines may be of the slow, medium or high speed type. They generally have no camshaft to drive fuel, air and exhaust systems but have common rail fuel/hydraulic arrangements and hydraulic actuating systems for the functioning of the fuel, air and exhaust systems.

15.1.3 The operation of these engines relies on the effective monitoring of a number of parameters such as crank angle, engine speed, temperatures and pressures using one or more electronic control systems to provide the services essential for the operation of the engine such as fuel injection, air inlet, exhaust and speed control.

15.1.4 Deviation from Rule requirements are to be submitted and will be specially considered.

15.1.5 During the life of the engine any changes to hardware, software, control and monitoring systems are to be submitted and approved by LR.

15.2 Plans and particulars

15.2.1 In addition to the plans and particulars required by Ch 1,2 the following information is to be submitted:

(a) A general overview of the operating principles supported by schematics explaining the functionality of individual systems and sub-systems. The information is to relate to the engine capability and functionality under defined operating and emergency conditions such as recovery from a failure or malfunction, with particular reference to the functioning of electronic control systems and any sub-systems. Also the information is to indicate if the engine has different modes of operation, such to limit exhaust gas emissions and/or to run under an economic fuel consumption mode or any other mode that can be controlled by electronic control systems.

(b) Details of hydraulic systems for actuation of sub-systems (fuel injection, air inlet and exhaust), to include details of the design/construction of pipes, pumps, valves, accumulators and the control of valves/pumps. Details of pump drive arrangements are also to be included.

(c) Failure Modes and Effects Analysis (FMEA) of the mechanical, pressure containing and electrical systems and arrangements that support the operation of the engine. The analysis is to demonstrate that suitable risk mitigation has been achieved so that a system will tolerate a single failure in equipment or loss of an associated sub-system such that operation of the engine will not be lost or degraded beyond acceptable performance criteria of the engine.

(d) A schedule of testing and trials to demonstrate that the engine is capable of operating as described in the design statement and any testing required to verify the conclusions of the FMEA.

(e) Operating manuals that describe particulars of each system and together with operating and maintenance instructions, to include reference to the arrangements for making modifications and changes to electronic control systems and for the functioning of sub-systems.

(f) Quality plan for sourcing, design, installation and testing of all components used in the oil fuel and hydraulic oil systems installed with the engine for engine operation.

(g) Fatigue analysis for all high pressure oil fuel and hydraulic oil piping arrangements required for engine operation where failure of the pipe or its connection or a component would be the cause of engine unavailability. The analysis is to concentrate on high pressure components and sub-systems and recognise the pressures and fluctuating stresses that the pipe system may be subject to in normal service.

(h) Schedule of testing at engine builders, pre-sea trial commissioning and sea trials. The test schedules are to identify all modes of engine operation and the sea trials are to include typical port manoeuvres under all intended engine operating modes.

(j) Evidence of type testing of the engine with electronic controls or a proposed test plan at the engine builders with the electronic controls functioning to verify the functionality and behaviour under fault conditions of the electronic control system.

15.2.2 In addition to the plans and particulars required by Pt 9 the following information for control, alarm, monitoring and safety systems relating to the operation of an electronically controlled engine is to be submitted:

(a) System requirements specification.

(b) Description of operation with explanatory diagrams.

(c) Line diagrams of control circuits.

(d) List of monitored points.

(e) List of control points.

(f) List of alarm points.

(g) List of safety functions and details of any overrides, including consequences of use.

(h) Details of hardware configuration.

(j) Hardware certification details.

(k) Software quality plan.

(l) System integration plan.

(m) Failure Mode and Effects Analysis (FMEA). *See* Pt 2, Ch 1,2.1.6

(n) Factory acceptance, integration, harbour and sea trials/test schedules for hardware and software.

(o) Software certification details.

(p) Quality plan for sourcing, design installation and testing of all components used in the control, alarm, monitoring and safety systems installed with the engine for engine operation.

15.3 Oil fuel and hydraulic oil systems

15.3.1 Oil fuel and hydraulic oil piping systems arrangements are to comply with Parts 7 and 8 as applicable.

15.3.2 Where pumps are essential for engine operation, not less than two oil fuel and two hydraulic oil pressure pumps are to be provided for their respective service and arranged such that failure of one pump does not render the other inoperative. Each oil fuel pump and hydraulic oil pump is to be capable of supplying the quantity of oil for engine operation at its maximum continuous rating and arranged ready for immediate use.

15.3.3 The oil fuel pressure piping between the oil fuel high pressure pumps and the fuel injectors is to be protected with a jacketed piping system capable of containing oil fuel leakage from a high pressure pipe failure.

15.3.4 The hydraulic oil pressure piping between the high pressure hydraulic pumps and hydraulic actuators is to be protected with a jacketed piping system capable of containing hydraulic oil leakage from a high pressure pipe failure.

15.3.5 Accumulators and associated high pressure piping are to be designed, manufactured and tested in accordance with a standard applicable to the maximum pressure and temperature rating of the system.

15.3.6 All valves, cocks and screwed connections are to be of a type tested type applicable to the maximum service conditions anticipated in normal service.

15.3.7 Isolating valves and cocks are to be located as near as practicable to the equipment that can be isolated. Note that all valves forming part of the oil fuel and hydraulic oil installation are to be capable of being controlled from readily accessible positions above the working platform.

15.3.8 High pressure oil fuel and high pressure hydraulic oil piping systems are to be provided with a high pressure alarm with a set point that does not exceed the system design pressure.

15.3.9 High pressure oil fuel and high pressure hydraulic piping systems are to be provided with suitable relief valves on any part of the system that can be isolated and in which pressure can be generated. The settings of the relief valves are not to exceed the design pressure. The valves are to be of adequate size and so arranged as to avoid an undue rise in pressure above the design pressure.

15.3.10 Equipment fitted for monitoring pressures and temperatures in the high pressure oil fuel and high pressure hydraulic oil systems is to comply with a recognised standard suitable to the anticipated vibration and temperature conditions.

15.3.11 The fatigue analysis is to be carried out in accordance with a standard applicable to the system under consideration and all anticipated pressure, pulsation and vibration loads are to be addressed. The analysis is to demonstrate that the design and arrangements are such that the likelihood of failure is as low as reasonably practicable. The analysis is to identify all assumptions made and standards to be applied during manufacture and testing of the system. Any potential weak points that may develop due to incorrect construction or assembly are also to be identified.

15.3.12 For high pressure oil containing and mechanical power transmission systems, the quality plan for sourcing, design, installation and testing of components is to address the following issues:

(a) Design and manufacturing standard(s) applied.
(b) Materials used for construction of key components and their sources.
(c) Details of the quality control system applied during manufacture and testing.
(d) Details of type approval, type testing or approved type status assigned to the machinery or equipment.
(e) Details of installation and testing recommendations for the machinery or equipment.

15.4 Electronic control systems

15.4.1 Plans and details of electronic control systems are to comply with Parts 9 and 10 as applicable.

15.5 FMEA analysis

15.5.1 Failure Mode and Effects Analysis (FMEA) is to demonstrate that a failure of the functioning of an electronic control system:

(a) Will not result in the loss of the ability to provide the services essential for the operation of the engine (*see* Pt 9, Ch 1,2.5.7 and 2.11.2).
(b) Will not affect the normal operation of the services essential for the operation of the engine other than those services dependent upon the failed part (*see* Pt 9, Ch 1,2.12.4 and 2.12.5).
(c) Will not leave either the engine, or any equipment or machinery associated with the engine, or the ship in an unsafe condition (*see* Pt 9, Ch 1,2.3.12, 2.4.5, 2.5.4, 2.9.3, 2.12.5).

15.5.2 Where FMEA analyses are required to be carried out the reports submitted need to address the following issues:

(a) Identify the standards used for analysis and system design.
(b) Identify the objectives of the analysis.
(c) Identify any assumptions made in the analysis.
(d) Identify the equipment, system or sub-system, mode of operation and the equipment.
(e) Identify potential failure modes and their causes.
(f) Evaluate the local effects (e.g. fuel injection failure) and the effects on the system as a whole (e.g. loss of propulsion power) of each failure mode.
(g) Identify measures for reducing the risks associated with each failure mode. This may be through system design, provision of redundant systems and/or quality control procedures for sourcing, manufacture and testing.
(h) Identify trials and testing necessary to prove conclusions.

15.5.3 At sub-system level it is acceptable to consider failure of equipment items and their functions, e.g. failure of a pump to produce flow or pressure head. It is not required that the failure of components within that pump be analysed. In addition, failure need only be dealt with as a cause of failure of the pump.

15.5.4 In an electronically controlled engine it is necessary to define the essential services on which the operation of the engine relies and the control functions, alarm functions and safety functions for the equipment and machinery providing these services, examples of essential services are:
(a) Starting arrangements.
(b) Fuel supply arrangements.
(c) Lubricating oil arrangements.
(d) Hydraulic oil arrangements.
(e) Cooling arrangements.
(f) Power supply arrangements.

See also Pt 1, Ch 2,17.

Volume 2, Part 2, Chapter 3
Steam Turbines

(Effective date 1 January 2005)

■ *Section 7*

Control and monitoring

7.4 Low vacuum and overpressure ~~protective~~ warning devices

7.4.1 To provide a warning of excessive pressure to personnel in the vicinity of turbine exhaust ends, s~~S~~entinel relief valves are to be provided at the exhaust ends or other approved positions of all main turbines, and the valve discharge outlets are to be visible and suitably guarded if necessary. Where a low vacuum cut-out device is provided, the sentinel relief valve at the L.P. exhaust may be omitted.

7.4.2 To provide a warning of excessive pressure to personnel in the vicinity of turbines exhaust ends, s~~S~~entinel relief valves are to be provided at the exhaust ends of all auxiliary turbines and the valve discharge outlets are to be visible and suitably guarded if necessary. Low vacuum or overpressure cut-out devices, as appropriate, are also to be provided for auxiliary turbines not installed with their own condensers.

Volume 2, Part 3, Chapter 2
Shafting Systems

(Effective date 1 January 2005)

■ *Section 4*

Design and construction

4.16 Sternbushes and sterntube arrangements

(Part only shown)
4.16.2 The length of the bearing in the sternbush next to and supporting the propeller is to be as follows:

(c) For oil lubricated bearings of synthetic material the flow of lubricant is to be such that overheating, under normal operating conditions, cannot occur. The acceptable nominal bearing pressure will be considered upon application and is to be supported by the results of an agreed test programme.

Existing items (c) to (e) are to be renamed (d) to (f)

4.16.5 Oil lubricated bearings of synthetic material are to be supplied finished machined to design dimensions within a rigid tube. Means are to be provided to prevent rotation of the lining within the tube during operation.

Existing paragraphs 4.16.5 to 4.16.9 are to be renumbered 4.16.6 to 4.16.10.

Volume 2, Part 4, Chapter 4
Podded Propulsion Units

CORRIGENDA

■ *Section 2*
General requirements

2.5 Failure Modes and Effects Analysis (FMEA)

2.5.2 The FMEA is to be carried out using the format presented in Table 2.17.1 in Vol 2, Pt 1, Ch 2 or an equivalent format that addresses the same reliability issues. Analyses in accordance with ~~IEC 60812: *Analysis for System Reliability – Procedure for Failure Mode and Effects Analysis*~~ *IEC 60812, Analysis techniques for system reliability - Procedure for failure mode and effects analysis (FMEA)*, or IMO MSC Resolution 36(63) Annex 4 – *Procedures for Failure Mode and Effects Analysis*, would be acceptable.

Volume 2, Part 5, Chapter 4
Shaft Alignment

(Effective date 1 January 2005)

■ *Section 2*
Details to be submitted

2.3 Design and installation criteria

(Part only shown)
2.3.2 Design and installation of the shafting is to satisfy the following criteria:

(d) Bearings of synthetic material are to be verified as being within tolerance for diameter, ovalness and straightness after installation.

Existing items (d) to (g) are to be renamed (e) to (h)

Volume 2, Part 7, Chapter 1
Piping Design Requirements

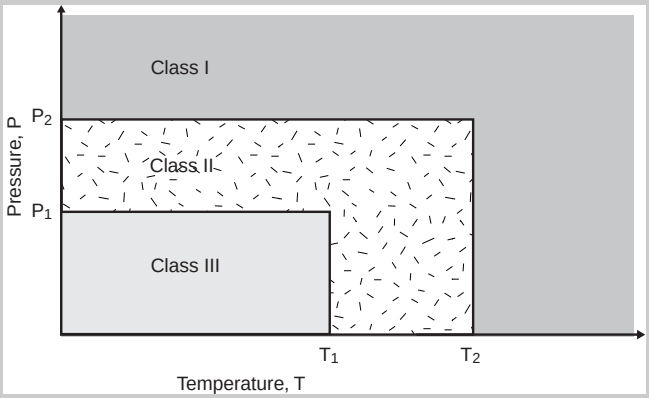
(Effective date 1 January 2005)

■ *Section 2*
General

2.3 Classes of piping system and components

2.3.2 Dependent on the service for which they are intended, Class II and Class III piping are not to be used for design pressure or temperature conditions in excess of those shown in Table 1.2.1. Where either the maximum design pressure or temperature exceeds that applicable to Class II piping systems, Class I piping is to be used. To illustrate, *see* Fig. 1.2.1. P_1 and T_1 correspond to the maximum pressures and temperatures for a Class III piping system and P_2 and T_2 to those for a Class II piping system depending on the service.

Fig. 1.2.1 Pressure/Temperature limits for Classes of piping



■ *Section 4*
Material

4.1 Metallic materials

4.1.5 The manufacturer's test certificate for materials for ship-side valves and fittings and valves on the collision bulkhead equal to or less than 500 mm nominal diameter will be accepted in lieu of LR's materials certificate where the valves and fittings are in accordance with a recognized National Standard applicable to the intended application and are manufactured and tested in accordance with the appropriate requirements of the Rules for Materials.

■ *Section 5*
Pipe connections

5.8 Welded sleeve joints

5.8.2 Welded sleeve ~~Sleeve~~ joints are not to be used in the following locations:

- ~~Piping for the storage, distribution and utilization of fuel, lubricating or other flammable oil systems in machinery spaces, *see also* Ch 3,4.5.1~~
- Bilge pipes in way of deep tanks.
- Cargo oil piping outside of the cargo area for bow or stern loading/discharge.
- Air and sounding pipes passing through cargo tanks.

5.8.3 Welded sleeve joints may be used in piping systems for the storage, distribution and utilisation of oil fuel, lubricating or other flammable oil systems in machinery spaces provided they are located in readily visible and accessible positions. *See also* Ch 3,2.8.2.

Existing paragraphs 5.8.3 to 5.8.6 are to be renumbered 5.8.4 to 5.8.7.

5.10 Mechanical connections for piping

Table 1.5.3 Application of mechanical joints
(Part only shown)

NOTES
1. Inside machinery spaces of category A - only approved fire resistant types.
2. Not inside machinery spaces of category A or accommodation spaces. May be accepted in other machinery spaces provided the joints are located in easily visible and accessible positions.
3. Approved fire resistant types. Fire resistant type is a type of connection which, when installed in the system and in the event of failure caused by fire, the failure would not result in fire spread, flooding or the loss of an essential service.
4. Above freeboard deck only.
5. In pump rooms and open decks - only approved fire resistant types.
6. If compression couplings include any components which are sensitive to heat, they are to be of approved fire resistant type as required for slip-on joints.
7. *See* 5.10.12.

■ *Section 8*
Cast iron piping and components

8.2 Grey cast iron

8.2.3 Grey cast iron is not to be used for the following:

- Pipes for steam systems and fire extinguishing systems.
- Pipes, valves and fittings for boiler blow-down systems and other piping systems subject to shock or vibration.
- Ship-side valves and fittings, *see* Pt 7, Ch 2,2.5.
- Valves fitted on the collision bulkhead, *see* Pt 7, Ch 2,3.3.
- Bilge lines in tanks.
- Pipes and fittings in flammable oil systems where the design pressure exceeds 7 bar or the design operating temperature is greater than 60°C.
- Valves fitted to tanks containing flammable oil under static pressure.
- Valve chests and fittings for starting air systems, *see* Pt 2, Ch 1,7.4.4.

■ *Section 12*
Valves

12.1 Design requirements

12.1.4 Where valves are required to be capable of being closed remotely in the event of fire, the valves, including their control gear, are to be of steel ~~they are to be of all-metallic~~ construction or of an acceptable fire tested design.

■ *Section 18*
Heat exchangers

18.1 General

18.1.1 The requirements in this Section are applicable to heat exchangers of the shell and tube type and plate type and which are necessary for the operation of Mobility and Ship Type engineering systems.

18.1.2 The requirements of this section are with the goal of providing heat exchange capability whereby normal operation of Mobility and Ship Type engineering systems can be sustained or restored when the performance of the heat exchanger has become degraded due to operating in normal sea-going conditions.

18.1.3 The number, type and capability rating of heat exchangers installed for Mobility and Ship Type engineering systems are to be adequate for all envisaged operating conditions taking into account all relevant ambient environmental conditions that may affect the performance of a heat exchanger.

18.1.4 Heat exchangers are to be installed such that where sea water is used for cooling purposes, the suction pipes to the supply pumps are to be provided with strainers which can be cleaned without interruption to the cooling water supply to the heater exchanger.

18.1.5 The design of heat exchangers is to be in accordance with an applicable and recognised standard acceptable to LR.

18.1.6 Heat exchangers are to be capable of stable operation at their specified rating under all envisaged operating conditions, *see* Pt 1, Ch 2,4. Any degraded performance under extreme environmental operating conditions is to be stated by the manufacturer and included in the design statement required by 18.1.10.

18.1.7 The selection of heat exchangers is to recognise the required functional performance of their intended duty in terms of effective heat transfer capacity, fluid media, fluid design flow rates and pressures, and, also recognise the design coefficient of heat transfer in different fouled conditions. *See also* 15.1.1.

18.1.8 Heat exchangers are to be capable of being cleaned when installed onboard. They are to be installed such that there are adequate access arrangements to permit cleaning and maintenance in accordance with the manufacturer's instructions.

18.1.9 To provide for venting of entrapped air from heat exchangers, high points on each fluid side of the heat exchanger not otherwise vented by fluid branches are provided with an air vent connection. Each air vent is to include a valve attached to the heat exchanger.

18.1.10 Heat exchangers are to be type tested in accordance with a specification acceptable to LR.

18.1.11 A design statement for each size and type of heat exchanger used in Mobility and Ship Type engineering systems is to be submitted for information purposes. The design statement is to include details of margins for fouling and plugging of tubes where applicable.

18.2 Materials

18.2.1 Materials used in the construction of heat exchangers are to be manufactured and tested in accordance with the requirements of Vol 1, Pt 2. For requirements of copper and copper alloy tubes intended for use in heat exchangers, *see* Vol 1, Pt 2, Ch 9,3.

18.2.2 Materials of heat exchangers are to be compatible with, and offer suitable erosion and corrosion resistance against, the intended fluid media. *See also* Vol 2, Pt 7, Ch 1,17. Sea-water wetted surfaces are to be non-ferrous or coated with a suitable rubber or plastic material where they are not part of the heat exchange system.

18.2.3 Means are to be provided to enable non-ferrous materials to be protected against the effects of exposure to polluted cooling water.

18.2.4 Combinations of incompatible materials are to be avoided, including those of the system pipe work in which the heat exchanger is to be fitted.

18.3 Shell and tube type heat exchangers

18.3.1 The design of shell, end boxes and fluid openings in shell and tube type heat exchangers is to ensure:

(a) Uniform distribution of fluids over and through the tubes.
(b) A smooth flow of the fluids from the inlet pipes to the tubes and from the tubes to the outlet pipes. In particular end boxes are to have sufficient depth to allow fluid to travel freely to all tubes. The minimum end box depth is to be at least equivalent to the internal diameter of the inlet/outlet connecting pipes.
(c) That pockets or obstructions which might interfere with fluid flow are avoided.
(d) That the water velocity complies with Pt 7, Ch 1, 17.6.3.
(e) That the form of hand holes and sight holes on end boxes preclude the formation of eddies.
(f) That the inclusion of internal ribs to provide a means of strengthening is avoided. However, there is to be sufficient support to avoid vibration of tubes in the tube-bundle which may detrimentally affect their specified life.
(g) That positive drainage of heat exchangers is provided. Drain valves, or for small heat exchangers drain plugs, are to be provided to ensure that tubes and shells are emptied and no large quantities of fluid are trapped in end boxes and shells.

18.3.2 Shell and tube type heat exchangers are to be arranged in the ship such that tube plates are readily accessible for cleaning/inspection and to allow for withdrawal of tubes for replacement without disturbing adjacent machinery.

18.3.3 Where ever practicable, viewing ports are to be provided on heat exchanger shell end boxes or covers to permit visual inspection of tubes, baffles and tube plates. In general, this will be limited to larger units of over 300 mm internal shell dimension.

18.4 Plate type heat exchangers

18.4.1 The design of the fluid openings and plates of plate type heat exchangers is to ensure:

(a) Uniform distribution of fluids through the plate passages.
(b) That pockets or obstructions which might interfere with fluid flow are avoided.
(c) Positive drainage of heat exchangers is provided. Drain valves, or for small heat exchangers drain plugs, are to be provided to ensure complete drainage.

18.4.2 Plate type heat exchangers are to be arranged in the ship such that plates are readily accessible for cleaning/inspection and to allow for withdrawal of plates for replacement with the minimum disturbance of adjacent pipe work.

18.5 Hydraulic testing

18.5.1 In general, heat exchangers are to be tested hydraulically to 1.5 times their maximum working pressures on the tube and shell sides or on both sides of the heat transfer plates as appropriate.

Volume 2, Part 7, Chapter 3
Machinery Piping Systems

(Effective date 1 January 2005)

■ *Section 4*
Oil fuel pumps, pipes, fittings, tanks, etc.

4.5 Pipes conveying heated oil

4.5.2 Where pipes convey heated oil under pressure the ~~The~~ flanges are to be machined, and the jointing material, which is to be impervious to oil heated to 150ºC, is to be the thinnest possible, so that flanges are practically metal to metal. The scantlings of the pipes and their flanges are to be suitable for a pressure of at least 13,7 bar or for the design pressure, whichever is the greater.

■ *Section 10*
Multi-engined ships

10.1 General

10.1.1 This Section is applicable to category **NS3 ships**, *see* Vol 1, Pt 1, Ch 2,2 that have multi-engine installations for propulsion purposes.

10.1.2 For vessels in which the propulsion systems are independent and the propulsion system prime movers are also fully independent of each other such that in the event of the failure of one of the sources of propulsion power the vessels will retain the capability of safely manoeuvring under all conditions of service, the following may not be required:

(a) Spare fuel oil booster pump stipulated in 3.11.2.
(b) Spare lubricating oil pump stipulated in 8.2.1(c), 8.2.2 and 8.2.3.
(c) Spare cooling water pump stipulated in 7.2.2(b).

■ *Section 11*
Electrical equipment cooling arrangements

11.1 General

11.1.1 Provision is to be made for an adequate supply of cooling to the electrical equipment used in Mobility and Ship Type engineering systems. The cooling arrangements may be worked from the engineering systems or be supplied by independent means.

11.1.2 The requirements of this Section are with the goal of providing sufficient cooling whereby normal operation of Mobility and Ship Type engineering systems can be sustained or restored even though any one of the sources of cooling becomes inoperative.

11.1.3 The temperature of cooling water supplied to coolers for electrical equipment is to take account of imposed loads when under normal design operating conditions and take into account the ambient temperatures likely to be experienced in the compartment where the equipment is located.

11.1.4 The possible formation of condensation due to low cooling temperatures where high humidity is likely to occur within electrical enclosures is also to be taken into account. The ambient temperatures and anticipated humidity levels are to be declared in the design statement required by 11.1.9.

11.1.5 Where chilled water systems are used for electrical equipment cooling, the arrangements are to comply with Ch 5 as applicable.

11.1.6 Where fresh water systems are used for electrical equipment cooling, the arrangements are to comply with Pt 11, Ch 1 as applicable.

11.1.7 Heat exchangers used in cooling systems for electrical equipment are to comply with Part 7, Chapter 1,18 as applicable.

11.1.8 Where sea-water systems are used for electrical equipment cooling, the guidance in Section 17 of Chapter 1 is to be complied with where applicable.

11.1.9 A design statement for cooling systems for electrical equipment used in Mobility and Ship Type category engineering systems is to be submitted for information purposes.

11.1.10 An FMEA is to be carried out for the cooling arrangements for electrical equipment used in Mobility and Ship Type category systems. The analysis is to be in accordance with Part 1, Chapter 2, 17 and is to address the effects of failure of cooling supplies related to the ability of equipment and systems to operate with short term loss of cooling and to operate with any reduced standby cooling capability.

11.1.11 Reference is also to be made to the following Rules as applicable:

(a) Location of pipes, joints and fittings - Pt 7, Ch 2,2.8.2.
(b) Cooling of electrical rotating machine enclosures - Pt 10, Ch 10,8.6.1.
(c) Cooling of transformers - Pt 10, Ch 1,9.1.10 and 9.1.11
(d) Cooling of semiconductor equipment - Pt 10, Ch 1,9.2.4 to 9.2.7.

11.2 Standby supply

11.2.1 Where the continuous operation of electrical equipment used in Mobility or Ship Type engineering systems is susceptible to interruptions in cooling arrangements (water or air), standby cooling arrangements are to be provided. In general, the standby cooling arrangements are to be automatically and immediately brought into effect on failure of the normal cooling supply. Such standby cooling arrangements may need to be supplied from an emergency source of power if the cooling is essential to the survivability of an item of equipment.

11.2.2 Where cooling arrangements is by cooling water system(s), provision is to be made for a separate supply of cooling water from a suitable independent pump of adequate capacity. The following arrangements are acceptable depending on the purpose for which the cooling water is intended:

(a) Where only one electrically powered Mobility system is fitted, the standby cooling arrangements are to be connected ready for immediate use.
(b) Where more than one electrically powered Mobility system is fitted, each with its own cooling pump, a complete spare pump of each type may be accepted. The complete spare pump is to be stored onboard such that can be readily installed if required.
(c) Where a sea inlet scoop arrangement is fitted, and there is only one independent cooling pump, a further pump, or a connection to the largest available pump suitable for cooling duties, is to be fitted to provide the second means of cooling when the ship is manoeuvring. The pump is to be connected ready for immediate use.
(d) Where fresh water cooling is employed for electrically powered Mobility systems, a standby fresh water pump need not be fitted if there are suitable emergency connections from a salt water system.
(e) Where each auxiliary item of electrically powered mobility equipment is fitted with a cooling water pump, standby means of cooling need not be provided.

Where, however, a group of auxiliaries is supplied with cooling water from a common system, a standby cooling water pump is to be provided for this system. This pump is to be connected ready for immediate use and may be a suitable general service pump.

11.3 Selection of standby pumps

11.3.1 When selecting a pump for standby purposes, consideration is to be given to the maximum pressure which it can develop if the overboard discharge valve is partly or fully closed and, when necessary, end covers, water boxes, etc., are to be protected by an approved device against inadvertent over-pressure.

11.4 Relief valves on main cooling water pumps

11.4.1 Where cooling water pumps can develop a pressure head greater than the design pressure of the system, they are to be provided with relief valves on the pump discharge to effectively limit the pump discharge pressure to the design pressure of the system. For location of relief valves, *see* Ch 2,7.6.

11.5 Sea inlets

11.5.1 Not less than two sea inlets are to be provided for the pumps supplying a sea-water cooling system, one for the main pump and one for the standby pump. Alternatively, the sea inlets may be connected to a suction line available to main and standby pumps.

11.5.2 Where standby pumps are not connected ready for immediate use (*see* 11.2.2(b)), the main pump is to be connected to both sea inlets.

11.5.3 Cooling water pump sea inlets are to be low inlets and one of them may be the ballast pump or general service pump sea inlet.

11.5.4 Auxiliary cooling water sea inlets are to be located one on each side of the ship.

11.5.5 Where sea inlets are connected to a common suction line serving main and standby cooling water pump units, the arrangements are to be such that a failure in the common suction line will not cause loss of sea-water supply to both pumps at the same time.

11.6 Strainers

11.6.1 Where sea-water is used for the direct cooling of electrically powered Mobility and Ship Type systems, the cooling water suction pipes are to be provided with strainers that will prevent debris being introduced into the cooling systems. The strainer arrangements are to be such that a strainer can be cleaned without interruption to the cooling water supply whilst the electrically powered equipment is in operation at its rated capacity.

11.6.2 In general, the aperture openings in primary strainers should not exceed 10 mm diameter and for secondary strainers not less than 5 mm diameter. The open area through any strainer is to be not less than twice the area of the inlet valve to the strainer. Where it is proposed to use secondary strainers with apertures less than 5 mm diameter, the implications of using such are to be assessed by the manufacturer and included in the operating and maintenance manual.

11.7 Cooling systems

11.7.1 Means are to be provided for the drainage and where necessary the storage of coolants, to enable maintenance and repair of the coolers and equipment.

11.7.2 All cooling systems are to be provided with means of venting air at high points and sufficient drain fittings to enable the system to be completely drained for maintenance.

11.8 Alarms

11.8.1 Cooling water systems for electrical equipment in Mobility and Ship Type engineering systems are to be provided with high temperature and low flow alarms.

Volume 2, Part 7, Chapter 4
Aircraft/Helicopter/Vehicle Fuel Piping and Arrangements

(Effective date 1 January 2005)

■ *Section 3*
Pump rooms

3.1 General

3.1.2 The pump rooms are to be totally enclosed and are to have no direct communication, through e.g. bilge piping systems and ventilation systems, with machinery spaces.

Volume 2, Part 9, Chapter 1
Control Engineering Systems

(Effective date 1 January 2005)

■ *Section 2*
Essential features for control, alarm and safety systems

2.6 Bridge control for main propulsion machinery

2.6.9 Automation systems are to be designed in a manner such that a threshold warning of impending or imminent slowdown or shutdown of the propulsion system is given to the officer in charge of the navigational watch in time to assess navigational circumstances in an emergency. In particular, the systems are to control, monitor, report, alert and take safety action to slow down or stop propulsion while providing the officer in charge of the navigational watch an opportunity to manually intervene, except for those cases where manual intervention will result in total failure of the engine and/or propulsion equipment within a short time, for example in the case of overspeed.

Volume 2, Part 10, Chapter 1
Electrical Engineering

(Effective date 1 January 2005)

■ *Section 1*
General requirements

1.2 Plans

1.2.1 At least three copies of the plans and particulars in 1.2.2 to 1.2.12 are to be submitted for consideration. Single copies only are required of plans in 1.2.13 to ~~1.2.16~~ 1.2.18. Additional copies are to be submitted when requested.

1.2.17 In order to establish compliance with the requirements of 1.6.3, evidence is to be submitted to demonstrate the suitability of electrical equipment for its intended purpose in the conditions in which it is expected to operate.

Existing paragraph 1.2.17 is to be renumbered 1.2.18.

1.6 Design and construction

1.6.3 Electrical equipment ~~shall be of a type tested and found suitable for use in a marine environment.~~ is to be suitable for its intended purpose in all conditions in which it expected to operate. Equipment is to be designed and constructed in accordance with appropriate international standards or, in the absence of such, relevant national standards or naval publications acceptable to LR and the Navy or Naval Authority. The design and construction is to take account of both functional and environmental requirements. For details of marine environmental conditions, reference should be made to Annex B of IEC 60092: *Electrical installations in ships - Part 101: Definitions and general requirements.*

1.7 Quality of power supplies

1.7.2 Unless specified otherwise, a.c. electrical equipment is to operate satisfactorily with the following simultaneous variations, from their nominal value, when measured at the consumer input terminals:

(a) voltage:
permanent variations +6%, -10%
transient variations due to step changes in load ~~+20%, -15%~~ ±20%
recovery time 1,5 seconds

(b) frequency:
permanent variations ±5%
transient variations due to step changes in load ±10%
recovery time 5 seconds
A maximum rate of change of frequency not exceeding ±1,5 Hz per second during cyclic frequency fluctuations.

1.9 Ambient reference and operating conditions

1.9.3 Main and essential auxiliary machinery and equipment is to operate satisfactorily under the conditions shown in Pt 1, Ch 2,4.5. Electronic appliances are to be suitable for proper operation even with an air temperature of 55ºC.

NOTE:
Details of local environmental conditions are stated in Annex B of IEC 60092: *Electrical installations in ships - Part 101: Definitions and general requirements.*

1.9.4 Where electrical equipment is installed within environmentally controlled spaces the ambient temperature for which the equipment is suitable for operation at its rated capacity may be reduced to a value not less than 35°C provided:

- the equipment is not for use for emergency services and is located outside of machinery space(s);
- temperature control is achieved by at least two cooling units so arranged that in the event of loss of one cooling unit, for any reason, the remaining unit(s) is capable of satisfactorily maintaining the design temperature;
- the equipment is able to be initially set to work safely within a 45°C ambient temperature until such a time that the lesser ambient temperature may be achieved; the cooling equipment is to be rated for a 45°C ambient temperature;
- alarms are provided, at a continually attended control station, to indicate any malfunction of the cooling units.

See also Pt 9, Ch 1, 1.3.3.

1.9.5 Where equipment is to comply with 1.8.4, it is to be ensured that electrical cables for their entire length are adequately rated for the maximum ambient temperature to which they are exposed along their length.

1.9.6 Equipment used for cooling and maintaining the lesser ambient temperature in accordance with 1.8.4 are considered essential services and are to satisfy the requirements of 5.2.

CORRIGENDA

1.14 Alarms

1.14.3 Cables for emergency alarms and their power sources are to be in accordance with ~~1.14~~ 1.15.

1.14.4 Electrical equipment and cables for emergency alarms are to be so arranged that the loss of alarms in any one area due to localised fire, collsion, flooding or similar damage is minimised, *see* ~~1.14~~ 1.15.

Effective date 1 January 2005

1.15 Operation under fire conditions

1.15.2 Where cables for the emergency services listed in 1.15.1 pass through high fire risk areas, main vertical or horizontal fire zones other than those which they serve, they are to be so arranged that a fire in any of these areas or zones does not affect the operation of the emergency service in any other area or zone. This may be achieved either by:

- cables being of a fire resistant type complying with 10.5.3, and at least extending from the main control/monitoring panel to the nearest local distribution panel serving the relevant area or zone; or
- there being at least two-loops/radial distributions run as widely apart as is practicable and so arranged that in the event of damage by fire at least one of the loops/radial distributions remains operational.

Areas of high fire risk include:

(a) Machinery spaces including diesel generator compartments and gas turbine compartments but excluding those spaces which do not contain machinery having a pressure lubrication system and where the storage of combustibles is prohibited.
(b) Galleys.
(c) Tanks containing liquids with a flash point lower than 60°C or with a temperature above 32°C.
(d) Compartments containing liquid oxygen.
(e) Fuel, petrol, oil or lubricant pump spaces.
(f) Magazines for munitions and armaments.

■ *Section 3*
Emergency and alternative sources of electrical power

3.1 General

3.1.3 Where the main sources of electrical power are located in two or more compartments that are not contiguous with each other, and where each source has its own independent self-contained systems, including power distribution and control systems, such that a fire or casualty in any one of the compartments will not affect the power distribution from the other(s), or to the services required by 3.2.5, the requirement of this section will be satisfied without an additional emergency source of electrical power and its associated transitional source of power, provided that:

(a) there is at least one generating set complying with the requirements of 2.2 and of sufficient capacity to meet the requirements of 3.2.5 in at least two non-contiguous compartments; and
(b) the generator sets referred to in 3.1.3(a) and their self-contained systems are installed such that one of them remains operable and readily accessible after damage or flooding in any one compartment; and
(c) the number and arrangements of generators is to allow for maintenance at sea of any one generator without affecting the ability to supply electrical power to the services in 3.2.5 from either of at least two compartments; and
(d) the requirements of this Chapter applicable to the emergency source or any associated equipment are to be applied to the main source complying with 2.2, or any associated equipment.

■ *Section 5*
Supply and distribution

5.1 Systems of supply and distribution

5.1.1 The following systems of generation and distribution are acceptable:

(a) d.c., two-wire;
(b) a.c., single-phase, two-wire;
(c) a.c., three-phase:
  (i) three-wire insulated;
  (ii) three-wire with neutral solidly earthed or earthed through an impedance;
  (iii) four-wire with neutral solidly earthed but without hull return.

■ *Section 7*
Switchgear and control gear assemblies

7.11 Instruments for alternating current generators

7.11.3 For parallelling purposes, two voltmeters, two frequency meters and two synchronising devices are to be provided. One voltmeter and one frequency meter are to be connected to the busbars, the other voltmeter and frequency meter are to be switched to enable the voltage and frequency of any generator to be measured. Where the electrical power requirement to maintain the ship in a normal operational and habitable condition is usually supplied by two or more generators operating in parallel, the two synchronizing devices are to be independent of each other (*see also* 2.2.1).

7.11.4 Where the indications of voltage, frequency, current and power are displayed digitally, in order to facilitate manual synchronising, the indications required by 7.11.3 are to be separately displayed.

7.12 Instrument scales

7.12.4 Where the indications provided by the instrumentation required by 7.11 are displayed digitally, nominal voltage, over voltage, over current and reverse power indications are to be indicated by an appropriate means.

■ *Section 19*
Lightning conductors

19.1 General

~~*19.1.1* Lightning conductors complying with IEC 60092-401 are to be fitted to each mast of all wood, composite and steel ships having wooden masts or topmasts. They need not be fitted to steel ships having steel masts.~~

19.1.1 In order to minimise the risks of damage to the ship and its electrical installation due to lightning, ships are to be provided with lightning protective arrangements in accordance with the applicable requirements of IEC 60092-401 *Electrical installations in ships. Part 401: Installation and test of completed installation* or an alternative and relevant National Standard.

Volume 2, Part 11, Chapter 3
Waste Systems

(Effective date 1 January 2005)

■ *Section 1*
General requirements

1.1 General

1.1.4 Where required by the Naval Authority, all Regulations of MARPOL Annex IV and Annex V are to be complied with.

1.2 Scope

1.2.1 Waste matter systems included in this Chapter cover the following:

(a) Sewage waste
(b) Galley waste
(c) Grey water
(d) Black water
(e) Solid waste
(f) Medical, sanitary, oil contaminated and hazardous waste.

Waste materials related to naval ship military operations are outside the scope of these requirements.

1.2.7 For the purposes of treatment and disposal: **solid waste** means food waste, plastics, medical waste, sanitary waste, oily rags and other dry waste such as paper, glass, metal, rags (non-oily) and packing materials. Contaminated NBC protective wear are not within the scope of this definition.

1.3 Plans and information

1.3.3 **Waste treatment and disposal plan.** A plan detailing the intended handling and treatment of solid waste is to be provided on board the ship. The plan is to detail the waste treatment procedures for all categories of solid waste with respect to the following criteria:

(a) Estimate of total production of each waste type per crew member for a specified period for each specific ship's voyages/missions,
(b) Processing facilities for solid waste matters, access and maintainability,
(c) Waste retention/storage facilities, including size and location on board the ship, access and separation,
(d) Overboard disposal of waste and permissions,
(e) Disposal of waste ashore and handling facilities,
(f) Treatment and handling of specialist waste, e.g. medical and oil contaminated waste,
(g) Hygiene,
(h) Waste segregation arrangements.

1.3.~~3~~ 4 **Systems.** Plans in diagrammatic form showing piping arrangements, control systems and safeguards and electrical systems covered by this Chapter. The major component parts, pipe sizes, system flow rates and pressures together with capacities of pumps and plants and tanks are to be included. Any Standards or Design Guidance used for system design are to be stated.

1.3.~~4~~ 5 **Compartments.** Plans showing the general arrangement of compartments, together with a description of the equipment and arrangements installed for handling, treatment, storage and disposal of waste and the electrical power supply systems. The plans are to indicate segregation and access arrangements for compartments and associated control rooms/stations.

1.3.~~5~~ 6 **Testing and trials procedures.** A schedule of testing and trials to demonstrate that systems are capable of operating as described in Section 3.

■ *Section 2*
Construction and installation

2.5 Coating of storage tanks and piping internal surfaces

~~2.6.1~~ 2.5.1 The storage tanks and metallic piping and valves are to be lined internally with a corrosion control coating suitable for the containment and transfer of waste matter.

~~2.6.2~~ 2.5.2 Corrosion control coatings are to be tested and certified as complying with standards specified by the Designer and agreed by the Naval Authority.

2.6 Plastics piping and flexible hoses

2.6.1 Subject to compliance with Pt 7, Ch 1,11 and 13, and the relevant sections of Pt 7, Ch 2, plastics piping may be used in piping systems for waste matter. Where storage tanks and metallic piping are constructed from materials that will not be affected by corrosion from waste matter, internal lining will not be insisted upon.

■ *Section 4*
Treatment of solid waste matter

4.1 General

4.1.1 Disposal of solid waste is to be in accordance with MARPOL Annex V.

4.1.2 Facilities are to be provided on board for the treatment and storage of all solid waste generated. In general, facilities are to be provided for the thermal destruction of solid waste on board to enable disposal of as much solid waste as possible when the ship is at sea.

4.1.3 Sufficient space is to be made available to store and secure all waste generated between sailing and next shore stop, or waste collection where there are no incineration facilities on board.

4.1.4 The storage facilities are to be sufficient in capacity for the storage of solid waste produced during the defined ship's missions and capability of any installed thermal destruction plant for solid waste disposal. This is to take into account voyages in special areas where disposal is prohibited.

4.1.5 The storage of solid waste is to be such that the waste is prevented from rotting, by provision of suitable cooling facilities where necessary. Alternatively the waste may be packed such that no gases or odours are spread.

4.1.6 Independent and safe storage spaces are to be available for medical, sanitary, oil contaminated and other hazardous wastes to ensure that such wastes are kept separate from each other and other solid wastes.

4.1.7 Each storage space shall be provided with adequate ventilation capacity and insulated, where necessary. Cooling facilities to comply with 4.1.5 may also be required. All spaces used for storage of solid waste are to be provided with fire detection equipment, and shelving within storage facilities are to be arranged in a grid so as to enable access for fire-fighting purposes.

4.1.8 Consideration shall be given to the location of treatment and storage rooms, in terms of separation from accommodation and communal areas. Similarly waste treatment and storage spaces are to be located so as to facilitate the convenient handling of waste on board the ship, and its transfer ashore.

4.1.9 Solid waste treatment plant, such as food waste pulpers, compactors and shredders, are to be suitable for their intended function. The capacity of the waste processing equipment is to be sufficient to process the specified amount of waste. Equipment for wastes treatment is not to produce toxic fumes, heavy smoke or excessive noise when functioning.

4.1.10 The arrangements in waste storage spaces are to allow easy access for cleaning. Drains in solid waste storage and treatment spaces are to be easy to clean and should prevent waste/dirt entering the system. In selecting deck coating and covering materials, consideration is to be given to ease of cleaning, and impact and corrosion protection. Sufficient space is to be available on all sides of waste treatment equipment to allow maintenance access.

4.1.11 When the ship is in harbour, all stored waste is to be normally disposed of ashore or retained on board when reception facilities are not available.

■ *Section ~~4~~ 5*
Control and monitoring and electrical power arrangements

~~4.1~~ 5.1 General

~~4.1.1~~ 5.1.1 The control engineering arrangements are comply with Pt 9, Ch 1 as applicable.

~~4.1.2~~ 5.1.2 Equipment used in waste systems is to be provided with local control and monitoring arrangements.

~~4.1.3~~ 5.1.3 Where isolation of equipment or systems can be carried out, means of indicating the status of isolation is to be provided at positions where the equipment and system can be operated and monitored.

~~*4.1.4*~~ *5.1.4* Instrumentation to indicate the operational status of running and any standby equipment is to be provided locally and at each control station.

~~*4.1.5*~~ *5.1.5* All pumps are to be provided with an indication of discharge pressure and a low discharge pressure alarm at the control station.

~~*4.1.6*~~ *5.1.6* The electrical engineering arrangements are to comply with Pt 10, Ch 1.

5.1.7 The control, supervision and monitoring of thermal destruction units is to comply with Pt 7, Ch 3,9.4 where applicable.

Existing Section 5 is to be renumbered Section 6.

Volume 3, Part 1, Chapter 4
Bridge Navigational Arrangements

(Effective date 1 January 2005)

■ *Section 1*
General requirements

1.1 General

1.1.1 The requirements of this Chapter apply to naval ships where an optional class notation for optimizing the environment on the bridge for navigational tasks including periodic operation of the ship under the supervision of a single watchkeeper on the bridge is requested, and are additional to those applicable in other Parts of the Rules.

~~*1.1.6* Where a ship is not intended to operate a periodic one man watch, but a notation to indicate a superior standard of equipment and bridge design is desired, the requirements of 4.2 and 4.3 may be relaxed and, in general, ships complying with the remainder of this Chapter will be eligible for the notation NAV.~~

Existing paragraph 1.1.7 is to be renumbered 1.1.6.

■ *Section 2*
Physical Conditions

2.1 Bridge and wheelhouse arrangement

2.1.1 The bridge configuration, arrangement of consoles and equipment location are to be such as to enable the officer of the watch to perform navigational ~~duties~~ tasks and other functions allocated to the bridge, as well as maintain an effective lookout. The following tasks are to be supported:

- navigation and manoeuvring;
- monitoring;
- manual steering;
- docking;
- planning;
- safety;
- communications; and
- conning.

2.1.4 From other workstations within the wheelhouse it is to be possible to monitor the navigation workstation and to maintain an effective lookout.

2.1.6 Clear passage of at least 700 mm width is to be available to allow movement around the bridge with a minimum of inconvenience. Particular attention is to be paid to the following routes which are to be as direct as possible:

(a) ~~from~~ From bridge wing to bridge wing, a clear passage of at least 1200 mm in width.

(b) ~~between~~ Between the internal entrance to the bridge and the route in (a) a clear passage of at least 700 mm in width is to be provided.

(c) Between adjacent workstations, a clear passage of at least 700 mm is to be provided.

(d) Between the bridge front bulkhead or any consoles and installations placed against the front bulkhead, to any consoles or installations placed away from the bridge front, a clear passage of at least 800 mm is to be provided.

Space necessary for operating at a workstation is to be considered as part of the workstation and is not to be part of the passageway.

2.1.7 The clear height between the wheelhouse deck surface covering and the underside of the deckhead is to be at least 2250 mm. ~~(or the~~ The lower edge of deckhead mounted equipment~~)~~ is to be at least 2100 mm in open areas, passageways and at standing workstations.

2.2 Environment

2.2.6 An adequate air conditioning or mechanical ventilation system, together with sufficient heating, according to climatic conditions, is to be provided in order to maintain the temperature of the wheelhouse within the range of 14°C to 30°C and the humidity within the range 20 per cent to 60 per cent. The discharge of hot or cold air is not to be directed towards bridge personnel. Control of this system is to be provided in the wheelhouse.

2.3 Lighting

2.3.1 The level of lighting is to enable bridge personnel to perform all bridge tasks, including maintenance and chart and office work, by day and night. Controls, indicators, instruments, keyboards, etc., on the bridge are to be capable of being seen in the dark either by means of internal lighting within the equipment or the wheelhouse lighting system. A satisfactory level of flexibility within the lighting system is to be available to enable the bridge personnel to adjust the lighting in brightness and direction as required in different areas of the bridge and by the needs of individual instruments and controls.

2.3.5 Lighting used in areas and at items of equipment requiring illumination, whilst the ship is navigating, is to be such that night vision is not impaired, e.g. red lighting. Such lighting is to be arranged so that it cannot be mistaken for a navigation light by another ship and so as to prevent glare and stray image reflections.

2.4 Windows

2.4.1 All wheelhouse windows are to be constructed of shatterproof toughened glass having a strength commensurate with the degree of exposure of the bridge to storm conditions and complying with a recognized National or International Standard, e.g. ISO *21005:2004 Ships and marine technology - Thermally toughened safety glass panes for windows and side scuttles.* ~~3254 Shipbuilding and marine structures - Toughened safety glass for rectangular windows.~~

2.4.2 Windows are to be as wide as possible and divisions between them are to be kept to a minimum. No division is to be positioned immediately forward of any workstation or on the ship's centreline.

■ *Section 3* Workstations

3.1 Navigation workstation

3.1.1 A workstation for navigation is to be arranged to enable efficient operation by one person under normal operating conditions. The workstation area is to be sufficient to allow at least two operators to use the equipment simultaneously. The arrangement of instruments and controls are to allow the use of all instruments and controls necessary for navigating and manoeuvring in any normal working position.

3.1.2 An adequate conning position is to be provided close to the forward centre window. If the view in the centreline is obstructed by large masts, ~~equipment~~ cranes, etc., two additional conning positions giving a clear view ahead are to be provided, one on the port side and one on the starboard side of the centreline, no more than 5 m apart. In addition to the conning position, a second position with a view of the area immediately in front of the bridge superstructure is to be provided close to a forward window or, alternatively, the conning position is to be wide enough to accommodate two persons.

3.1.4 The following facilities are to be provided at the navigation workstation:

- Radar and radar plotting facilities (*see* 3.1.5);
- position fixing system displays (*see* 3.1.6);
- echo sounder display;
- speed and distance indications (*see* 3.1.10 and 3.1.11);
- gyro compass display (*see* 3.1.7);
- magnetic compass display;
- wind speed and direction indication;
- steering controls and indication (*see* Vol 2, Pt 6, Ch 1,7);
- rate of turn indication;
- course/track controls and indications (*see* 3.1.8 and 3.1.9);
- main propulsion and thruster controls and indication (*see* Vol 2, Pt 9, Ch 1,2.6);
- watch safety system acknowledge;
- watch safety system manual initiation;
- internal communications system;
- VHF radiotelephone;
- time indication;
- window clear view controls;
- navigation lights controls;
- whistle control;
- morse light keys;
- wheelhouse/equipment lighting controls;
- automatic ship identification system (AIS) information~~.~~;
- sound reception system where fitted (*see* 2.2.8).

3.1.14 Electrical and electronic equipment shall be installed ~~in~~ so that electromagnetic interference does not affect the proper function of the navigational systems and equipment. ~~The~~ Installation ~~should comply with~~ of the equipment in accordance with the guidelines and recommendations included in IEC 60533 *Electrical and electronic installations in ships - Electromagnetic compatibility* ~~or an acceptable equivalent standard~~ would generally be considered to meet the requirement.

■ *Section 4* Systems

4.1 Alarm and warning systems

4.1.2 The following alarms are to be provided:

- closest point of approach;
- shallow depth;
- waypoint approaching (where automatic track following is provided);
- off-course;
- off-track (where automatic track following is provided);
- steering alarms (*see* Table 1.8.1 in Vol 2, Pt 6, Ch 1 or Table 2.6.1 in Vol 2, Pt 4, Ch 3 as applicable);
- navigation light failure;
- gyro compass failure;
- watch safety system ~~(where provided)~~ failure;
- failure of any power supply to the distribution panels referred to in 4.4.1.

4.2 Watch safety system

4.2.1 A watch safety system satisfying the requirements of the IMO performance standards for a bridge navigational watch alarm system (BNWAS) and approved by the Naval Authority is to be provided to monitor the well-being and awareness of the watchkeeper ~~is to be provided~~. The system is not to cause undue interference with the performance of bridge functions.

4.2.2 The watch safety system is to automatically become operational whenever the ship's heading or track control system is activated.

Existing paragraphs 4.2.2 to 4.2.4 are to be renumbered 4.2.3 to 4.2.5.

4.2.6 Visual warning indications are to be visible, and audible warning indications are to be audible, from all operational positions on the bridge where the watchkeeper may reasonably be expected to be stationed. The colour of visual indicators is not to impair night vision.

~~*4.2.5*~~ *4.2.7* In the event that the watchkeeper fails to respond and accept the warning or if any alarm has not been acknowledged on the bridge within a period of 30 seconds, the system is to immediately initiate a watch alarm to warn the Commanding Officer and the appointed back-up navigator through a fixed installation. ~~Manual initiation of the watch alarm from the bridge is to be possible at any time.~~

4.2.8 In the event that the watch alarm is not acknowledged, the system is to initiate the watch alarm at the locations of further crew members capable of taking corrective actions following a time delay sufficient to allow the Commanding Officer or backup navigator to reach the bridge. The time interval is to be adjustable between 90 seconds up to a maximum of 3 minutes. The watch alarm to warn the further crew members may be initiated at the same time as the watch alarm to warn the Commanding Officer and backup navigator.

4.2.9 The watch alarms which sound in the locations of the Commanding Officer, officers and further crew members capable of taking corrective action should be easily identifiable by its sound and should indicate urgency. The volume of this alarm should be sufficient for it to be heard throughout the locations above and to wake sleeping persons.

4.2.10 Manual initiation of the watch alarm from the bridge is to be possible at any time.

~~*4.2.6*~~ *4.2.11* The system is to be designed and arranged such that only the ship's Commanding Officer has access for enabling and disabling it and setting the appropriate intervals, ~~and such that it cannot be operated in an unauthorized manner~~ so as to prevent accidental or unauthorized operation, e.g. removing the fuses or keeping the acknowledgement button permanently depressed either accidentally or deliberately.

Existing paragraphs 4.2.7 to 4.2.9 are to be renumbered 4.2.12 to 4.2.14.

4.2.15 Failure of the watch alarm system is to activate an audible and visual alarm at the centralized alarm system.

■ *Section 5*
Integrated Bridge Navigation System - IBS notation

5.2 General requirements

5.2.1 For assignment of the notation **IBS**, the ~~ship is also to be assigned either **NAV** or **NAV1**.~~ layout of the bridge and the equipment on the bridge are to satisfy the requirements for assignment of the notation **NAV1** (Sections 1 to 4). Where the layout of the bridge and the equipment located on the bridge satisfy the requirements of a relevant international or national ergonomic or human centred design standard or an acceptable equivalent, compliance with the requirements of Sections 1 to 4 may be relaxed.

5.2.2 The design features for computer hardware, local area networks and software required by Vol 2, Pt 9, Ch 1,2.9, 2.10, ~~and~~ 2.11 and 2.12 respectively are to be complied with. Alarms associated with hardware and data communication are to be incorporated in the centralized alarm system required by 4.1.

Volume 3, Part 1, Chapter 5
Propulsion and Steering Machinery Redundancy

(Effective date 1 January 2005)

■ *Section 1*
General requirements

1.1 General

1.1.2 The requirements, which are optional, cover machinery arrangements and control systems necessary for ships which have propulsion and steering systems configured such that, in the event of a single failure ~~in~~ of a system or item of equipment, the ship will retain ~~in operation~~ the ability to use not less than 50 per cent of the installed prime mover capacity and not less than 50 per cent of the installed propulsion systems and retain steering capability at a service speed of not less than seven knots. The requirements also cover machinery arrangements where the propulsion and steering systems are installed in separate compartments such that, in the event of a loss of one compartment, the ship will retain availability of propulsion power and manoeuvring capability.

CORRIGENDA

■ *Section 2*
Failure Mode and Effects Analysis (FMEA)

2.1 General

2.1.2 The FMEA is to be carried out using the format presented in Table 5.2.1 or an equivalent format that addresses the same safety issues. Analyses in accordance with ~~IEC 600812, *Analysis for System Reliability – Procedure for Failure Mode and Effects Analysis*~~ IEC 60812*, Analysis techniques for system reliability - Procedure for failure mode and effects analysis (FMEA)*, or IMO MSC Resolution 36(63) Annex 4 – *Procedures for Failure Mode and Effects Analysis*, would be acceptable.

Volume 3, Part 1, Chapter 7
Replenishment at Sea (RAS) Systems

CORRIGENDUM

■ *Section 2*
Principles

2.3 Class notations

2.3.1 Ships complying with the applicable requirements of this Chapter will be eligible for machinery class notations.

RAS(ABV): Ships having arrangements to enable RAS operations astern, abeam and VERTREP.

RAS(AB): Ships having arrangements to enable RAS operations abeam and astern only.

RAS(AV): Ships having arrangements to enable RAS operations astern and VERTREP.

RAS(BV): Ships having arrangements to enable RAS operations abeam and VERTREP.

RAS(A): Ships having arrangements to enable RAS operations astern only.

RAS(B): Ships having arrangements to enable RAS operations abeam only.

RAS(V): Ships having arrangements to enable RAS operations VERTREP only.

Volume 3, Part 2, Chapter 2
Environmental Protection

(Effective date 1 January 2005)

■ *Section 2*
Environmental Protection (EP) class notation

2.4 Refrigeration Systems

2.4.2 The use of chlorofluorocarbons (CFC) in refrigeration or air conditioning installations is prohibited. ~~However, installations containing hydrochlorofluorocarbons (HCFC) are permitted until 1 January 2020.~~

■ *Section 3*
Supplementary characters

3.8 Oxides of sulphur (SO_x) - S character

3.8.1 For assignment of the **S** character, all gas oil used onboard is to have a sulphur content of less than 0,20 per cent m/m. All heavy fuel oil is to have a sulphur content of less than ~~1~~ 1,5 per cent m/m.

Cross-references

Volume 1, Part 1, Chapter 2

1.6.1 Reference to paragraph 3.9.10 *now reads* 3.9.9.
Reference to paragraph 3.9.13 *now reads* 3.9.12.

4.8.4 Reference to paragraph 4.4.2 *now reads* 4.4.3.
Reference to paragraph 4.4.3 *now reads* 4.4.4.

4.8.5 Reference to paragraph 4.4.5 *now reads* 4.4.6.

Volume 1, Part 3, Chapter 2

3.4.10 Reference to Section 11 *now reads* 10.

Volume 1, Part 3, Chapter 5

1.3.2 Reference to Section 5 *now reads* 4.
Reference to Section 6 *now reads* 5.
Reference to Section 7 *now reads* 6.
Reference to Section 9 *now reads* 8.
Reference to Section 10 *now reads* 9.

5.3.2 Reference to sub-Section 9.3 *now reads* 8.3.

5.4.5 Reference to paragraph 5.6.1 *now reads* 4.6.1.

6.2.5 Reference to paragraph 6.2.3 *now reads* 5.2.3.

7.4.6 Reference to paragraph 7.4.5 *now reads* 6.4.5.

7.4.7 Reference to paragraph 7.4.5 *now reads* 6.4.5.

7.4.10 Reference to paragraph 7.4.5 *now reads* 6.4.5.

7.5.2 Reference to paragraph 7.4.1 *now reads* 6.4.1.

8.4.2 Reference to paragraph 8.6.5 *now reads* 7.6.5.

8.4.3 Reference to paragraph 8.6.11 *now reads* 7.6.11.

8.5.12 Reference to paragraph 8.6.11 *now reads* 7.6.11.

8.6.4 Reference to paragraph 8.6.2 *now reads* 7.6.2.
Reference to paragraph 8.6.3 *now reads* 7.6.3.

8.6.5 Reference to paragraph 8.6.3 *now reads* 7.6.3.

9.1.3 Reference to paragraph 9.2.3 *now reads* 8.2.3.

9.2.1(b)(i) Reference to paragraph 9.2.1(a) *now reads* 8.2.1(a).

9.2.2 Reference to paragraph 9.2.1 *now reads* 8.2.1.
Reference to paragraph 9.3.2 *now reads* 8.3.2.

9.3.1 Reference to paragraph 9.2.1 *now reads* 8.2.1.

10.3.3 Reference to paragraph 10.5.1 *now reads* 9.5.1.

Volume 1, Part 3, Chapter 6

5.1.2 Reference to paragraph Pt 1, Ch 2,3.9.6 *now reads* Pt 1, Ch 2,3.9.5.

Volume 1, Part 4, Chapter 1

2.2.4 Reference to paragraph Pt 1, Ch 2,3.9.10 *now reads* Pt 1, Ch 2,3.9.9.

2.2.7 Reference to paragraph Vol 2, Pt 1, Ch 2,4.8 *now reads* Vol 2, Pt 1, Ch 2,4.9.

Volume 1, Part 4, Chapter 2

5.3.4 Reference to paragraph Vol 2, Pt 1, Ch 2,4.10 *now reads* Vol 2, Pt 1, Ch 2,4.11.

Volume 2, Part 1, Chapter 2

3.3.10 Reference to sub-Section 4.11 *now reads* 4.12.

3.3.11 Reference to sub-Section 4.10 *now reads* 4.11.

3.3.12 Reference to sub-Section 4.9 *now reads* 4.10.

3.3.13 Reference to sub-Section 4.12 *now reads* 4.13.

4.5.1 Reference to Table 2.4.1 *now reads* Table 2.4.2.

4.5.2 Reference to Table 2.4.1 *now reads* Table 2.4.2.

4.5.3 Reference to Table 2.4.1 *now reads* Table 2.4.2.

4.5.4 Reference to Table 2.4.1 *now reads* Table 2.4.2.

4.6.2 Reference to paragraph 4.6.1 *now reads* 4.7.1.

4.9.3 Reference to Table 2.4.2 *now reads* Table 2.4.3.

4.10.1 Reference to paragraphs 4.10.2 to 4.10.27 *now reads* 4.11.2 to 4.11.27.

4.10.2 Reference to paragraph 4.10.1 *now reads* 4.11.1.

4.10.4 Reference to paragraph 4.10.5 *now reads* 4.11.5.
Reference to paragraph 4.10.27 *now reads* 4.11.27.

4.11.1 Reference to paragraphs 4.11.2 to 4.11.14 *now reads* 4.12.2 to 4.12.14.

4.15.1 Reference to paragraphs 4.15.2 to 4.15.4 *now reads* 4.16.2 to 4.16.4.

4.15.4 Reference to paragraph 4.15.2 *now reads* 4.16.2.

4.16.3 Reference to sub-Section 4.15 *now reads* 4.16.

4.19.2 Reference to Table 2.4.3 *now reads* Table 2.4.4.

4.19.4 Reference to paragraph 4.19.1 *now reads* 4.20.1.

5.4.1 Reference to Table 2.4.1 *now reads* Table 2.4.2.

16.2.1(h) Reference to Section Vol 1, Pt 3, Ch 5,8 *now reads* Vol 1, Pt 3, Ch 5,7.

Volume 2, Part 2, Chapter 1

1.4.1 Reference to Pt 1, Ch 2, Table 2.4.1 *now reads* Pt 1, Ch 2, Table 2.4.2.

8.2.6 Reference to paragraph Pt 1, Ch 2,4.14 *now reads* Pt 1, Ch 2,4.15.

Volume 2, Part 2, Chapter 2

1.5.1 Reference to Pt 1, Ch 2, Table 2.4.1 *now reads* Pt 1, Ch 2, Table 2.4.2.

Volume 2, Part 2, Chapter 3

1.4.1 Reference to Pt 1, Ch 2, Table 2.4.1 *now reads* Pt 1, Ch 2, Table 2.4.2.

Volume 2, Part 4, Chapter 4

6.8.2 Reference to sub-Section Pt 1, Ch 2,4.5 *now reads* Pt 1, Ch 2,4.6.

Volume 2, Part 7, Chapter 1

13.2.3 Reference to sub-Section Pt 1, Ch 2,4.8 *now reads* Pt 1, Ch 2,4.9.
Reference to sub-Section Pt 1, Ch 2,4.10 *now reads* Pt 1, Ch 2,4.11.

Volume 2, Part 7, Chapter 3

2.3.3 Reference to sub-Section Pt 1, Ch 2,4.5 *now reads* Pt 1, Ch 2,4.6.

8.5.1 Reference to sub-Section Pt 1, Ch 2,4.5 *now reads* Pt 1, Ch 2,4.6.

Volume 2, Part 7, Chapter 4

2.2.12 Reference to Pt 1, Ch 2,4.18 *now reads* Pt 1, Ch 2,4.19.

Volume 2, Part 7, Chapter 5

3.1.14 Reference to Pt 1, Ch 2, Table 2.4.1 *now reads* Pt 1, Ch 2, Table 2.4.2.

Volume 2, Part 10, Chapter 1

1.1.7 Reference to sub-Section Pt 1, Ch 2,4.8 *now reads* Pt 1, Ch 2,4.9.

1.9.1 Reference to sub-Section Pt 1, Ch 2,4.8 *now reads* Pt 1, Ch 2,4.9.

1.10.1 Reference to Pt 1, Ch 2,Table 2.4.1 *now reads* Pt 1, Ch 2, Table 2.4.2.

1.11.8 Reference to sub-Section Pt 1, Ch 2,4.8 *now reads* Pt 1, Ch 2,4.9.

1.11.11 Reference to sub-Section Pt 1, Ch 2,4.8 *now reads* Pt 1, Ch 2,4.9.

8.1.1 Reference to sub-Section Pt 1, Ch 2,4.8 *now reads* Pt 1, Ch 2,4.9.

10.10.2 Reference to sub-Section Pt 1, Ch 2,4.8 *now reads* Pt 1, Ch 2,4.9.

Volume 2, Part 11, Chapter 1

3.3.11 Reference to Pt 1, Ch 2, Table 2.4.1 *now reads* Pt 1, Ch 2, Table 2.4.2.

5.2.1 Reference to sub-Section Pt 1, Ch 2,4.5 *now reads* Pt 1, Ch 2,4.6.

Volume 2, Part 11, Chapter 2

1.2.6 Reference to sub-Section Pt 1, Ch 2,4.11 *now reads* Pt 1, Ch 2,4.12.

2.6.3 Reference to sub-Section Pt 1, Ch 2,4.11 *now reads* Pt 1, Ch 2,4.12.

3.1.2(g) Reference to sub-Section Pt 1, Ch 2,4.11 *now reads* Pt 1, Ch 2,4.12.

5.2.1 Reference to sub-Section Pt 1, Ch 2,4.5 *now reads* Pt 1, Ch 2,4.6.

Volume 3, Part 1, Chapter 7

6.1.8 Reference to sub-Section Vol 2, Pt 1, Ch 2,4.18 *now reads* Vol 2, Pt 1, Ch 2,4.19.

9.1.12 Reference to sub-Section Vol 2, Pt 1, Ch 2,4.18 *now reads* Vol 2, Pt 1, Ch 2,4.19.

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